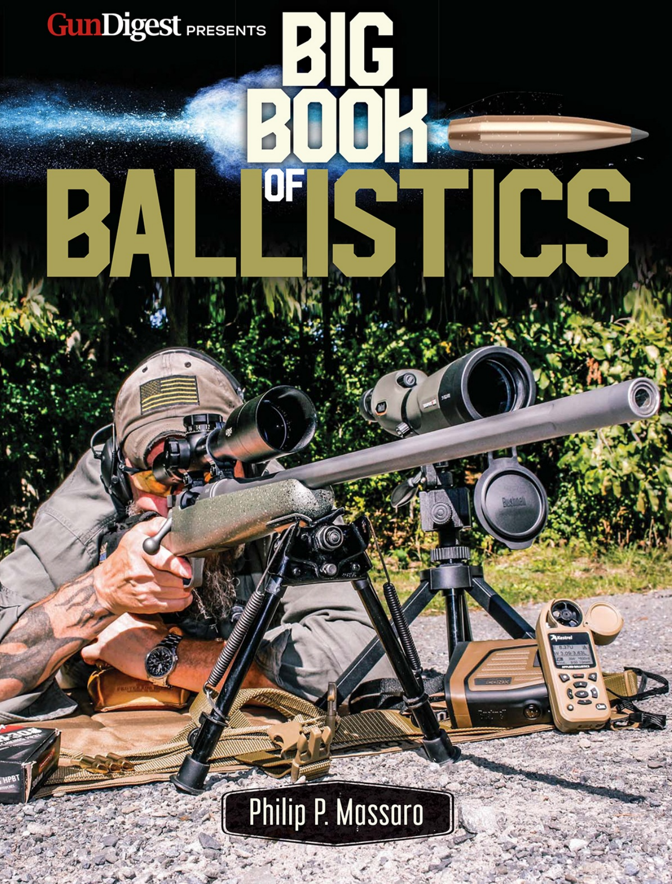
Gun Digest PRESENTS

BIG BOOK OF BALLISTICS



Philip P. Massaro

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DEDICATION

This book is dedicated to Tim Fallon, Doug Pritchard and the entire crew of the FTW Ranch in Barksdale, Texas, who have been more than kind in both word and deed, and who were instrumental in the development of this book. Without the SAAM Shooting School, I would still be in the dark ages.

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FOREWORD

In a life and career solely dedicated to hunting and shooting, it has been my pleasure to know most of the recognized experts and innovators in the industry. Among these are some of my very best friends, people with whom I’ve forged lifelong professional relationships. We share the same passion for the shooting sports, run in the same crowds, and live similar lifestyles. We also enjoy a mutual and burning passion for sending bullets down the barrel of a good rifle at

different targets, and for different purposes.

Among these men is Phil Massaro, head honcho of Massaro Ballistic Laboratories, LLC and the brainpower behind the book you are holding. A native of Upstate New York, (I forgave him for that long ago) Phil has been quickly rising through the ranks of the long list of skilled American gun writers. But it is Massaro's knowledge of — and ability to explain — the confusing science of ballistics, where he pulls away from the rest of the field. Whether your

target is flesh and bone, paper, or steel plate, the goal is to place your bullet, regardless of distance, weather conditions, or wind precisely where you want it to go. And regardless of your rifle, caliber, or ability to hold steady for the shot, understanding ballistics, and all that term entails, is the key to accurate shooting.

I make no claims to being a ballistics expert. In fact, I shy away from deep conversations about the subject as to not highlight my ignorance. Oh, I can usually drive my bullet to a target in the hunting

fields of the world, but it is practice, combined with an intimate knowledge of my personal rifles and my own limitations that has filled my trophy room over the years.

But I like to shoot, and I like to learn, and Phil is a guy with which I greatly enjoy doing both. Recently, at the beautiful FTW Ranch in central Texas, Massaro and I joined our good friends Tim Fallon and Doug “Dog” Prichard for a four-day training session at the now famous SAAM Precision Shooting School.

SAAM stands for Sportsman All-Weather, All-Terrain Marksmanship, and there is no finer training ground for the serious hunter and shooter to be found. Massaro and I were both officially on hand in the role of students under the tutelage of Prichard, who is one of the finest shots and training experts this country's military has ever produced. Actually, while I really was a student, Massaro could have run the course himself as a trainer, so thorough is his understanding of both the science, and mechanics of accurate shooting. We

teamed up for the course and helped each other out with range and wind estimates, target conformation, and calling hits and misses.

I left my ego at the ranch gate, and really dedicated myself to learning on this trip. With both Prichard and Massaro overseeing my efforts in both the classroom and on the ranges, I enjoyed the most enlightening four days in my shooting career. Indeed, a better understanding of ballistics was the key to my learning. And that is exactly what Big Book of Ballistics provides: a wealth of

easy to understand information on the world of accurate shooting.

Massaro writes like he talks, and his goal of providing understandable information in real world terms hits the target. He skillfully unravels the science of interior, exterior and terminal ballistics, and reveals methods for accurate shooting which will make sense to both SEAL sniper, and serious big-game hunter.

Between these covers you will learn about trajectory, wind deflection, interior ballistics and barrel effects including

twist rates, bullet profiles, sectional density and bullet coefficient, terminal ballistics and modern improvements in projectiles, spin drift and Coriolis effect, as well as improved gear for today’s shooter. But far more importantly, you will understand what you read! That’s where this book shines.

Massaro’s contributions to publications such as *Gun Digest*, *American Hunter*, and *GameTrails* is a testament to the fact that he regularly puts his knowledge to use in the game fields. In fact, this is a driving theme you will see revealed as

you turn the pages of this book — that understanding the principals of ballistics is the most important step in becoming a successful and ethical hunter.

I have seen Phil Massaro put a precise hole in the shoulder of a Cape buffalo, and I have seen him center punch a 20-inch steel plate at 1,250 yards. Both shots were sent with equal confidence from a man who makes a habit of practicing what he preaches when it comes to shooting.

Some books are tilted toward serious teaching, while others are

more for entertainment. Big Book of Ballistics is a unique blend of the two, and both purposes will have been fully served between the first page and the last.

Bwana Massaro has preached, and I on bended knee have heard … and learned.

– Dave Fulson, Safari Classics

INTRODUCTION

Ballistics is defined by Merriam-Webster's Dictionary as *1. The science of the motion of projectiles in flight*, *2. The study of the processes within a firearm as it is fired*. This book will expound on both of those definitions.

I was taught at an early age that knowledge is power, and I firmly believe that this statement applies to shooters, especially in this day and age of advanced cartridges, rifles and projectiles. When we venture forth to use

our firearms, a working knowledge of mechanical functions of both the gun and the ammunition will only enhance our ability to hit the chosen target, be it a game animal or paper bullseye, a metal plate or silhouette target. The rapid advances of firearms technology in the 19th century forced our forefathers to adapt to a new technology; within the span of one lifetime, flintlocks gave way to percussion cap guns, and to metallic cartridge repeating rifles. The simple, round lead ball was pushed aside for Minie balls, and ultimately jacketed

bullets. The 20th century saw a similar evolution: cordite and other early propellants were replaced by single- and double-based nitrocellulose powders, and the radical advances in bullet technology in the latter half of that century produced many new and wonderful designs, so many that the choices can sometimes be dizzying.

The study of ballistics can be a rather daunting endeavor. Many people prefer to remain happily ignorant of the particulars, just enjoying a firearm in the manner that they know how to use it, and

that's fine if they choose to do so. Others, like myself, are very interested in what makes things tick, in hopes to better the performance at the target range or in the hunting fields. However, the deeper one delves into the study of a spinning projectile — and the effects of our atmosphere upon that projectile — the more things start to sound like Chinese algebra. Quantifications are something we humans thrive on, and the mathematical formulae used to represent the speed, energy and attributes of a particular projectile are effective, but like

most things in life, they don’t tell the complete story.

The myriad terms associated with ballistics have become household words to me, but that is because I spent my cavity-prone years poring over reloading manuals and shooting books. First things first, some confessions. I am not, in any way, shape or form, a physics major. Being a licensed land surveyor, I am not afraid of mathematics, but I am easily bored by the half-page equations that are required to explain bullet drop and wind drift. That said, it will be important to

have a full understanding about how these factors affect your chosen projectile, so that you can adjust your firearm to perform the way you want, delivering a humane kill or proper placement on the target.

I will do my best, within the covers of this tome, to explain these formulae and their effects in plain speech, and while we're going to have to get technical sooner or later, all efforts will be made to offer the science in a palatable manner, without writing a book that is a legal cure for insomnia. There are three major

sections involved in our study: interior, exterior and terminal ballistics. Interior ballistics is the study of those processes that happen from the instant the trigger is pulled and the firing pin strikes the primer, until your projectile leaves the muzzle of the barrel. Exterior ballistics covers the bullet's journey from muzzle to target, be it a long flight of several hundred yards, or a short jaunt measured in feet. Finally, terminal ballistics covers exactly what happens when a projectile strikes a target made of flesh and bone, and the various types of bullet

construction. I will do my best to discuss various cartridges, how they function, and why they have gained (or lost) popularity. I will dispel some myths, and compare and contrast one cartridge versus another, as well as certain bullet types and/or weights within a particular cartridge.

While science is used to best explain the world around us, and the numerous factors that affect how things behave, understand that this book will not be a definitive essay on the art of ballistics. I call it an art, because there is much more involved than a white lab coat and a PhD

in order to make a distant shot, or place several bullets on the bullseye; we as humans are ultimately in control of the inanimate object that is the firearm, and I think the human conditions that affect a bullet’s path warrant discussion.

Some folks (we call them ballisticians) devote their life to the study of a bullet’s journey from cartridge to target, and may be much better qualified to speak on certain matters than this author. “Every man must know his limitations,” the saying goes, and where I feel there are those whose knowledge is greater than

my own, I have contacted those people for their wisdom and insight. Believe me, I learned a whole lot during the course of this project, and am grateful for the input and insight those kind people have offered.

One of the beauties of the firearm itself is the instant ability to hit your target; unlike archery, where the flight of the arrow can be seen, the rifle or pistol seems to magically touch the target, with no more evidence of the bullet’s flight than a loud report, some recoil, and the mark on the target board or game animal.

We need to slow things down and examine what's going on in a step-by-step procedure, so that when we amplify the distances at which we are trying to hit a target we can see — at least in our mind's eye — the path of the bullet and how we need to adjust for it. We will examine the conformation and configuration of the various metallic cartridges, to make better-informed decisions, and suit our hunting or shooting needs best. And lastly, we will look at some of the bullet designs, and explain their function in the real world.

While this is not the type of book that is full of incredible stories of hunting or shooting prowess, one that fuels the daydreams during the darkest days of modern civilization — those days where we are trapped in an office — this book will (hopefully) inform those who will one day write those stories. After all, the successes you experience behind the trigger are rarely made by accident, but instead the result of hours of diligent practice and the desire to expand your knowledge of firearms and how to best use them. The same can be said for the

associated tools that aid you in delivering the bullet on target: you must understand the application in order to best put them to use.

Let us begin the study.

SECTION I
INTERIOR BALLISTICS

SECTION I: **GUNDEX®**

CHAPTER 1
INTERIOR BALLISTICS OVERVIEW

The sequence that a fired metallic cartridge undergoes is a small wonder in and of itself. The design hearkens back to the mid-19th century, and with the exception of the composition of the components, not all that much has changed. Yes, the propellants have

become small scientific wonders (we’re going to get to that shortly) while the projectiles of today are engineering marvels. However, the actual processes aren’t that much different when comparing 2016 and 1876, and aren’t altogether strange when compared to those 140 years ago.

Rimfire cartridges hold the priming compound in the rim of the cartridge.

For all of our centerfire cartridges, the basic process is as follows: The loaded cartridge is secured into the chamber of the firearm, where the rear and sides of

the cartridge are sealed within the steel chamber; the only exit point is down the barrel. The firing pin strikes the primer — located in the center of the cartridge case head — and the chemical compound is smashed against an interior anvil, resulting in a shower of sparks. Those sparks are forced through the flash hole, a term which reaches back to the days of flintlock rifles, and ignites the powder charge located inside the large chamber of the cartridge. Once that powder charge is ignited, the burning powder generates all kinds of pressure, and there is only

one possible result: the bullet (which is pressed into the cartridge case) is forced out of the case, and sent down the barrel, where it has an inevitable meeting with the rifling of the barrel, and begins rotating rapidly.

The rimfire cartridge works in the same manner, except that the priming is contained in the rim of the cartridge and integral with it. Muzzleloading firearms use the actual breech to form a chamber, with the spark coming from an external source, be it a pan full of flash powder, a No. 11 percussion cap or — in the case of

the modern muzzleloaders — a 209 shotgun primer.

In any of these cases, the load can only generate the amount of pressure that the steel chamber can adequately handle. Now, while that may sound relatively simple, there are a multitude of factors that can have both negative and positive effects on the consistency and performance of the resultant flight of the bullet. Powder burn rate, powder charge weight, primer heat, chamber volume, bullet weight — the list goes on and on.

We’ll carefully compare and contrast those features.

There are volumes that have been written about the size, shape and performance of certain cartridges, so much so that these stories have evolved into a sort of gospel, and with some people there’s no point in discussing it because no amount of explanation or logic is going to change their minds. Whether the cartridge is one of the U.S. military adoptees, or Grandpa’s favorite meat-maker, it’s the be all and end all. Let’s take a look at certain cartridges with

a clean slate, and try to draw some logical conclusions as to why they have a particular reputation — good or bad — and attempt to draw some educated conclusions about some of the cartridges that are often overlooked.

Keep in mind that any cartridge is just a combustion chamber, at least when looking at it from the view of the projectile, and while there are those cartridges that may feed better than others, or that may result in a lighter weight rifle or handgun, the bullet doesn’t give a hoot; it just knows that

there is a particular powder charge and pressure created that has just propelled it from zero to pretty-damned-fast, and that it has met the rifling to start spinning on its journey to glory.

The 7.62x51 NATO made a splash in the hunting world as the .308 Winchester.

The shape and construction of the bullet will have a definite effect on the interior ballistics, almost an equal effect as will be found during exterior and terminal ballistics phases. The powder will have a correlative effect, in the amount of pressure developed and the velocity at which the bullet is launched. The length and configuration of the barrel can and will have a definite effect on how that bullet will fly, too, and you need to know those specifications to best match the ammunition to the barrel, to get the best performance out of your firearms.

So, your chamber is loaded with a cartridge, and the sear has released the firing pin. That primer is just about to be crushed, and that’s where we’ll pick up our study.

CHAPTER 2

THE CARTRIDGE CASE

The little brass wonder we call the cartridge case is the basis for the whole shebang: it contains the primer, powder charge and bullet. There have been many fantastic designs since things became pretty well standardized by the 1870s. Some of these designs are still popular, like the .45 Colt (1873), the .45-70 Government (1873), the .44-40 WCF

(1873), the 7x57mm Mauser (1892), .303 British (1889) and the .30-30 WCF (1895). The early 20th century saw some radical developments in bullet design and powder composition, which directly affected the design of the brass cartridge. Many of those early designs became the classics that we all know very well, cartridges like the .30-06 Springfield, .375 Holland & Holland Magnum, .404 Jeffery, .250/3000 Savage, .45 ACP, .38 Special and .35 Remington, all released between 1900 and 1915. The trend showed that as the higher pressures

became attainable — from the advent of smokeless powders coupled with the strength of the copper-jacketed bullet — cartridges in general started to shrink in both bore diameter and case capacity, yet they got the job done.

Holland & Holland's .375 rimless belted magnum.

The .44-40 Winchester, a cowboy classic.

As anyone with experience with different calibers will attest, there are

very, very few hunting situations that couldn't be handled with one of the cartridges that I've listed above. As a matter of fact, they are all still available in modern production rifles a century later, and they comprise an irrefutable set of classic cartridges.

Between the World Wars, cartridge development continued and we saw velocities climb in cartridges like the .270 Winchester and the .300 Holland & Holland Magnum, both in 1925. After the Second World War, even the U.S. Government began to make the shift

toward smaller cases using powders that generated higher pressures. The military was seeking to replace the .30-06 Springfield with a cartridge just as effective ballistically, yet cut down in size and weight so the soldier could carry more ammunition in the field. The resulting T-52 — or as we know it in its civilian form, the .308 Winchester — came to fruition after testing began with the .300 Savage cartridge. It morphed into the .308 Winchester we all know and love, and delivered the exact parameters the Government was after: a lighter,

higher-pressure .30-06, delivering muzzle velocities so close that it didn’t really matter in a combat situation.

The 1950s and 1960s were a veritable renaissance of cartridge development, and the faster/shorter/lighter trend continued. Winchester released its foursome of belted cartridges, the .264 Winchester Magnum, .338 Winchester Magnum, .458 Winchester Magnum and lastly, the .300 Winchester Magnum, all based on the .375 H&H case shortened to .30-06 length. Remington followed suit with the 7mm Remington Magnum.

(Remington wasn’t quite done though, taking the short-fat idea to unprecedented levels with the 6.5 Remington Magnum and .350 Remington Magnum, both based on the H&H belted case, but cut to fit into a .308 Winchester-length action.) The short, squat trend had begun, but it would take until the late 1990s for it to make another commercial appearance, when Winchester announced the arrival of their Short Magnum series, including .270, 7mm, .30 and .325 calibers. These WSM cases were a derivative of the Remington Ultra Magnum, a .375 H&H-

length cartridge based on a blown-out .404 Jeffery. Winchester then took it to an altogether new level with the Winchester Super Short Magnum — in .223, .243 and .25 calibers — for a cartridge that resembles a fire hydrant.

The original quartet of Winchester Magnums, the .300, .264, .338 and .458.

Then there are the cartridges designed specifically for punching paper, and delivering serious accuracy. The .22PPC

and 6mm PPC, designed by Dr. Louis Palmisano and Ferris Pindell really set the benchrest world on its proverbial ear in the 1970s, breaking nearly every record possible. Then the F1 folks discovered the 6.5-284 Norma, and long-range accuracy took on a new meaning. The 6mm Bench Rest Norma and Remington cases produce some fantastic results, as well as David Tubbs' 6mmXC.

So, as we take this cursory look at cartridge history, you can see that things are constantly evolving, in an attempt to create the most efficient design possible.

I find it humorous and almost ironic when I see someone print a tiny group with a .30-06 Springfield; it almost seems to have been all for naught. However, I do feel that there is room for all of the different variations, just as long as someone identifies with it. We shooters have spent way too much time and energy debating the minute differences in energy and velocity figures, instead of learning how to maximize the rifle/cartridge combination that we’ve chosen in the field or at the range.

Holland’s Super .30.

There is a theory among cartridge designers, and those Louis Palmisano-designed PPC cartridges come immediately to mind, that a short, fat powder column will burn more efficiently

than will a long, skinny column. To a degree, I can buy that, especially in reference to the .308 Winchester, .300 WSM and 6.5 Creedmoor, as the primer's spark will reach a larger cross-section of the powder in that configuration than in the long, narrow cartridges. But on the flip side, I've seen some incredible performance from the longer cartridges like the .300 Remington Ultra Magnum, .300 Winchester, and 6.5-284 Norma.

The .300 H & H Magnum, or Holland's Super .30 as it's also known, has a long, sloping 8-degree 30-minute

shoulder, and headspaces off of the belt at the cartridge base, but was used by Ben Comfort to win the Wimbledon Cup at Camp Perry in 1935, and again another 1,000 yard match in 1937. But yet, few would consider it to be an ‘efficient, well-designed target cartridge.’ That .300 H&H has, in more than one rifle I’ve shot and/or loaded for, proven to be an exceptionally accurate cartridge. Conversely, I’ve seen some rifles chambered for the .300 Winchester Short Magnum — a cartridge often touted for its ‘inherent accuracy,’ and the holder of a

few 1,000-yard records — that didn’t even give mediocre accuracy, regardless of measures taken to improve it. It really depends on what your requirements are in a cartridge, and what your ultimate goal is. Is it a target gun, with which you need to reach out to 600, 700 or 1,000 yards? Is it a hunting gun, which will only be asked to perform within sane hunting ranges? Perhaps it will be some combination of both attributes. We will discuss cartridge features, and how they affect the interior ballistics of the rifle to

help you make a better-informed decision.

Rimmed pistol cartridges.

Rimless pistol cartridges.

The same concepts can easily be applied to pistol cartridges. While the pressures are often lower than their rifle counterparts, the design of the cartridge

itself, and how it functions within the process of discharging the firearm, effect its performance. Wheelguns, generally speaking, can withstand a much higher chamber pressure than most of the semi-automatics, yet both are highly useful in their respective applications. The cartridges are generally of two designs: the rimmed cartridges (.38 Special, .357 Magnum and .44 Remington Magnum) and the rimless cartridges (9mm Luger, .40 S&W and .45ACP). Again, speaking in generalities until we delve a bit deeper, the rimmed pistol cartridges use that rim

for headspacing, while the rimless pistol cartridges use the case mouth for headspacing.

WHAT IS HEADSPACING?

Headspacing requires some discussion, as it can have an effect on the way a cartridge works within the firearm’s chamber, and can definitely impact the accuracy of your firearm.

Headspace is the distance from the base of the cartridge case to the point on the cartridge case that prevents the cartridge from moving any farther forward in the chamber.

To put this into real-world, appreciable terms, I’ll give some examples.

A rimmed cartridge, whether straight-walled, tapered, or bottlenecked, uses the thickness of the cartridge rim for its headspacing. It is a positive method of headspacing, resulting in very uniform results, yet these cartridges don’t often feed well in bolt- or pump-action magazine rifles. They do very well in lever-action rifles and revolvers, as well as single-shot and double rifles. Examples include the .30-30 Winchester,

.45-70 Government, .22 Long Rifle, .38 Special and .357 Magnum.

The rimmed .30-30 WCF.

The rimless bottleneck cartridges, like the .223 Remington, .308 Winchester, .30-06 Springfield and .270 Winchester, have an extractor groove cut into the base

of the case, just north of the case head. As a result, these cartridges use the shoulder of the bottleneck for headspacing. The shoulder is typically quite steep, upwards of 15 degrees (though there are exceptions like the .404 Jeffery) to prevent the cartridge from moving any farther forward in the chamber. The rimless bottleneck design works perfectly in almost all repeating rifles, from lever to bolt to semi-automatic, to the military's fully-automatic, belt-fed machine guns. So long as the firearm is properly

headspaced, this bottlenecked rimless design will work as intended. The groove allows for excellent extraction, too; it’s a design common among many of our most famous cartridges.

Rimless bottleneck rifle cartridges.

Rimless .45 ACP cartridges.

The rimless, straight-walled cartridges comprise the most common choices for the modern, semi-automatic pistols. This style of cartridge uses the same extractor

groove as its bottlenecked cousins, but since there is neither rim nor shoulder, it headspaces off the case mouth. Note that this feature is especially important to those who handload this style of cartridge, as the projectiles cannot be ‘roll-crimped’ into the case; they must be taper crimped, or held in place by the use of a special die which squeezes the side wall of the cartridge around the shank of the bullet. In this type of cartridge, the case length is of utmost importance as that distance is the sole dimension responsible for setting the headspacing. If

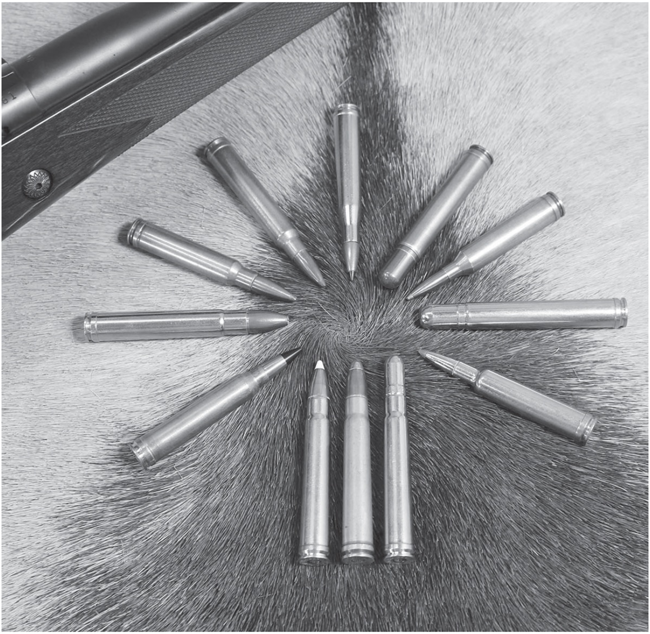
you’ve ever picked up a 9mm Luger or .45 ACP that has a rather ‘sooty’ look around the mouth of the case, it is an example of poor (excessive) headspacing, either from the firearm’s chamber being too long, or the ammunition being too short. The .40 Smith & Wesson, as well as the 9mm Luger and .45 ACP, are all examples of pistol cartridges that headspace off of the case mouth.

The belted cartridges, based on the famous Holland & Holland design of the early 1900s, are a hybrid of the rimmed and rimless design. Because the rimmed

design gave such fantastic headspacing, but didn't feed very well from a box magazine, and the London firm didn't want to rely on a steep shoulder for headspacing (both the .375 H&H and .300 H&H have gentle, sloping shoulders), they built a small shelf, or belt of brass into the case wall, just above the extractor groove. So, in essence, the H&H belted cartridges use a "rimmed-rimless" case, which feed perfectly in repeating rifles, yet headspace off of the rim. Thus, the shoulder dimension is irrelevant. While it is commonly thought

that the .375 H&H Rimless Belted Magnum — the .375 H&H we all know and love — was the first cartridge released that featured the now-famous belt, that isn't true. In 1905, Holland & Holland released the .400/.375 Belted Nitro Express, also known as the .375 Velopex, but its performance was poor in comparison to other Nitro Express cartridges of the era, so it didn't last long. Additionally, when the .375 H&H was released in 1912 it wasn't alone. The .275 Holland & Holland Magnum, with a 2.500-inch case length and the same belt

was released simultaneously. Firing a 7mm projectile at some very familiar velocities, the .275 H&H Magnum is, in theory, the 7mm Remington Magnum. It just took 50 years for the shooting world to realize they wanted it!



Belted cartridges.

Since the belt on any belted cartridge is there for headspacing, and has nothing to do with case strength, it’s rather ironic that there are so few belted cases that actually headspace off of that belt. Certainly the .375 H&H and .300 H&H, and I’d definitely include the .458 Winchester Magnum, .458 Lott, and the .450 Marlin, but the plethora of belted magnums (including the .300 Winchester and 7mm Remington Magnum, as well as the entire Weatherby family of cartridges) all headspace off of the shoulder. Now, I know what you’re thinking: in the last

half of the 20th century, no self-respecting “magnum” cartridge would be caught dead without its belt. It’s a very good point, but I think that the .375 H&H case was used as the basis for the brood of offspring ranging from the .257 Weatherby up to the .458 Lott — not for the ‘strength’ of the belt or for headspacing issues, but for the case capacity of the parent cartridge.

Let’s break the cartridges down, based on their rim types. There are five main classifications of rims, as follows:

Rimmed .45-70 Government cartridges.

RIMMED

This cartridge has a rim that extends beyond the diameter of the case body (bet you never saw that coming!), which serves to hold the case in the chamber. It also serves as a positive depth guide for headspacing. The earliest cartridge

designs were rimmed, designed for single-shot and early lever-action rifles, and the first revolvers. Some rimmed cartridge examples are the venerable .30-30 WCF, .357 Magnum, .303 British, .32 Winchester Special and .45-70 Government.

RIMLESS

Rimless cartridges use a rim the same diameter as the case body, with a groove machined into the area just in front of the case head. Rimless cases headspace on either the cartridge shoulder (for a bottle-necked case) or the case mouth (for some

straight-walled cases). The firearm’s extractor grabs the case by the groove in front of the case head. This design greatly facilitates cartridge feeding from a spring-loaded magazine. These cartridges saw the light of day in the late 1880s. Some examples are the .308 Winchester, .30-06 Springfield, 5.56mm NATO, .45 ACP, .40 S&W, 7x57mm Mauser, and .25-06 Remington.

Rimless rifle cartridges.

The semi-rimmed .25ACP.

SEMI-RIMMED

Possibly the rarest type, semi-rimmed have a very small amount of rim extending past the diameter of the case body, but not nearly as much as a rimmed case. They were designed for the positive headspacing capability of the rimmed cartridge, while coming close to achieving the ease of feeding from a magazine that the rimless cartridges possess. Examples of semi-rimmed cases are the .25 ACP and the .444 Marlin.

REBATED RIM

This is a case that uses a rim dimension smaller than the diameter of

the case body, the rim only serving the purpose of extraction. This is a feature seen on the Winchester Short Magnum series and the Remington Ultra Magnums, and is designed to have huge case capacity for high velocities. Other examples of rebated rim cartridges are the .50 Beowulf, .500 Jeffery, 6.5-284 Norma and .284 Winchester.

The rebated rim of the .458 SOCOM.

Belted magnums.

BELTED MAGNUM

The belted magnum case dates back to 1910, has a “belt” of raised brass ahead

of the extractor groove, yet a case head designed similarly to the rimless cases. The theory behind this design was to provide easy feeding from a rifle’s box magazine (a la rimless), while offering the positive headspacing from the rim, and not the shoulder (a la rimmed). The British firm of Holland & Holland first offered it in their .375 Velopex (which never caught on) and used it again in their .375 Belted Rimless Nitro-Express in 1912, better known as our African classic .375 H&H Magnum. This case led to the development of the Super .30, or

.300 Holland & Holland Magnum in 1925, and it was this belted case design that would be the basis for nearly every case that had “Magnum” in its name, including the Weatherby line, until the Winchester Short Magnums and Remington Ultra Magnums came along at the turn of the 21st century. These newer Magnum cases are primarily based on the beltless .404 Jeffery.

CASE CAPACITY: HOW MUCH IS TOO MUCH?

As time goes by, and smokeless powder continues to develop slower burn

rates, both the velocities and pressures of our cartridges continue to increase. It really doesn’t matter what category of cartridges we are discussing, things are getting faster. The .17 Winchester Super Magnum in the rimfire world; the 6.5-300 Weatherby and .300 Remington Ultra Magnum in the medium centerfire realm; the .460 Smith & Wesson in the pistol department; one can easily see how the love affair with speed has not wavered in the least. But, there are circumstances where even though we’ve created a cartridge that has the potential for

unprecedented velocity, we may have reached the point of diminishing returns. Obviously, to reach these unprecedented figures, you must use a considerable amount of slow burning powder. Can all that powder be burned in a barrel of manageable length? Does that powder charge generate such incredible pressures (recoil) that the average shooter will deem it unshootable?


HODGDON

The .300 Remington Ultra Magnum has a huge appetite for powder.

I know for certain that some of the faster magnum cartridges — the .257 Weatherby being one of the culprits — will produce a visible 12- to 18-inch muzzle flame at high noon on a bright sunny day. That flame is produced, in part, by unburnt powder. I've seen the same thing from my .300 Winchester Magnum and factory loads that use lighter bullets at a high velocity; while the ammo was wonderfully accurate, it

turned the rifle into a fire-breathing dragon. Now, that isn’t necessarily a bad thing if the velocity/bullet combination is suitable for the job at hand, be it a game animal or distant bullseye, but there are certain caveats that must be addressed.

One, barrel wear and throat erosion. Launching a bullet at velocities of about 3,300 fps or faster has shown to have a significant effect on the throat and barrel of a rifle, especially if the shooter fires a number of shots in succession. Cartridges like the .264 Winchester Magnum, .26 Nosler, 6.5-300 Weatherby, .300

Remington Ultra Magnum and their ilk have been responsible for short barrel life, throat wear, and a reputation for a degradation of accuracy in less than 1,000 shots. I use some of these cartridges in hunting rifles (not target rifles) but I’m very careful to avoid heating the barrel excessively.

Additionally, in the search for flat trajectories and the highest velocities possible, powder consumption drastically increases. If you’re shooting factory ammunition, this may be a moot point, but to the handloader it represents a

serious increase in costs. Let’s look at three differing .30 caliber cartridges, at three distinct levels of performance. We’ll use the loads for a good old 180-grain bullet — a popular choice for big game — and powders that are well-suited to each cartridge. The .30-06 Springfield, which has long proven itself to be the benchmark of .30 caliber cartridges, uses just about 60 grains of suitable powder before the load becomes compressed and the grain structure of the powder runs the risk of being broken. Velocities run between 2,700 fps and 2,800 fps,

depending on your rifle and chosen powder. The .300 Winchester Magnum, which has long represented the most you could get out of a standard long-action rifle (until the .30 Nosler came along) can cram just about 76 grains of powder before compression, giving velocities in the neighborhood of 3,050 fps to 3,100 fps; a definite increase in both velocity and trajectory. Bump up to the .300 Remington Ultra Magnum, and you'll easily run 95 grains of slow burning powder, with pressure becoming excessive before you're able to fill the

case. The .300 RUM obtains velocities of up to 3,350 fps with that huge powder charge, but it’s not hard to see why long shooting sessions with a cartridge like this will definitely heat up your barrel, as well as put a strain on a bullet as it jumps from the cartridge mouth into the rifling. With this class of cartridge, I prefer to keep my groups to three shots. If I’m getting serious about hunting accuracy, I allow the barrel to cool to ambient temperature between shots, to assess what the rifle will do with a cold barrel,

which represents most of the hunting scenarios.

Does this mean that these cartridges are trouble? Or at least that they aren’t worth the fuss? I don’t think so, but you need to realize that the interior ballistics of these ‘super-magnums’ can have an effect on the rifle, and that they need to be treated a bit differently than, say, a .308 Winchester or .35 Whelen.

CASE FUNCTION AND INTERIOR BALLISTICS EFFECTS

The brass cartridge case is nothing more than a combustion chamber. It is designed to withstand a prescribed amount of pressure when housed within the steel chamber of the rifle or pistol. That pressure, generated by the burning powder within the case, is what forces the bullet down the barrel. The case is subjected to the violent forces of the process, and expands from the standard dimension to become a mirror of the firearm’s chamber. If the pressures are too great, the case will become ‘stuck’ in the chamber and will be difficult to

extract. There are tell-tale signs of this scenario: primers that are flattened and/or cratered, where you can see the metal of the primer cup molded around the firing pin imprint, showing that the powder ignition created a pressure so great that the primer metal was violently pressed rearward toward the bolt face. You may see the brass of the case head flowing around the extractor of the bolt face; this is another indication of extreme pressures. Difficult extraction, as stated above, is an obvious sign that things are getting dangerous. Heck, I’ve seen people

use a mallet to beat open a bolt-action rifle when using ammunition that reached dangerously high pressures.

Cartridge cases ready for loading.

For the best accuracy, things need to be uniform, and that includes the cartridge case and powder charge. In order to launch bullets in a uniform manner, you need to generate the most consistent pressures possible. If there are variations in the cartridge case dimensions, the size of the combustion chamber changes and the pressures (read velocities) will vary accordingly. Those pressure changes can result in a loss of accuracy, even if you do your part as a shooter. This is the idea behind match-grade cases; they strive to give the most uniform dimensions

possible, to keep things consistent. Serious benchrest shooters tune their cartridge cases, turning the case necks to a constant dimension, reaming the flash holes to a uniform diameter, and use the best sizing dies so all the cases maintain a consistent configuration. If you shoot only factory ammunition, you’re at the mercy of the production techniques of the manufacturer, but if you’ve experimented with Federal’s Gold Medal Match line, Norma’s wonderful ammunition, Nosler’s Handloaded Series or the Hornady Match stuff, you’ve more than likely seen an

increase in accuracy. Now, that’s not to say that the traditional ammunition is inaccurate, but a more consistent production technique leads to a more uniform (accurate) product, all things being equal.

Norma’s American PH ammunition.

Load density within the case can have an effect on the accuracy of your chosen combination. While a heavily compressed load in a rifle case can break the grain structure and slightly vary the pressure —

especially with an extruded stick powder — a load that best fills the case will provide the best accuracy. Again, there will be exceptions to this rule, but it’s what I’m looking for as a handloader. In a pistol case, it will be nearly impossible to fill the case, and as the cases are so much shorter than their rifle counterparts, the load density doesn’t pose as great of an issue. The load density of factory loaded ammunition, which can and does use a blended powder mixture, is out of your control, and as the factories are loading ammo for a broad range of firearms, it’s

easy to understand why not every gun likes all types of ammunition (we'll get to this further when we discuss barrels and their harmonics).

CASE CAPACITY AND PRESSURE

Not all brass cartridge cases are created equal, and if you're a reloader you may already be familiar with this. If you're shooting factory ammunition, you'll want to experiment with different types and brands to find what your gun likes best, preferably by obtaining a large quantity of that ammo from the same lot.

That way you can keep things as uniform as possible.

If you reload, become a brass hoarder; every single empty cartridge should be snatched up for future use. As you develop your pet loads, closely following your recipe for all the accuracy you can muster, keep detailed notes regarding all of the components and their performance. On more than one occasion, I've had fellow reloaders tell me that a load that has worked well for a period of time has suddenly lost accuracy or sent a flier (a shot that prints out of the normal group

size) without explanation. Or, the cartridge cases show signs of excess pressure, perhaps cratered primers, sticky extraction, or brass flowing around the extractor on the case head. And, quite often, the answer is a cartridge case of different brand, giving a different capacity. That difference in capacity yields a different pressure, and therefore a different velocity (in the case of a flier) or raises the pressure generated up to an unsafe level, should the case capacity be smaller than that with which the load was developed.

Again, as with all aspects of accuracy, uniformity is paramount. Many shooters that enjoy the popular military rifle calibers — 5.56 NATO, 7.62 NATO and .30-06 Springfield — have access to surplus ammunition and brass cases. As a general rule of thumb, military brass cases are quite a bit thicker than sporting ammunition, and if you were to use the same powder charge that worked in a Federal case, for example, I wouldn’t be shocked if you saw both a change in point of impact and possibly excessive pressures. For this reason, I keep all of

my brass cases sorted by brand, and the nickel-plated cases separate from the plain brass variant.

Brass and nickel-plated cases.

Crimped .357 Magnum cartridges.

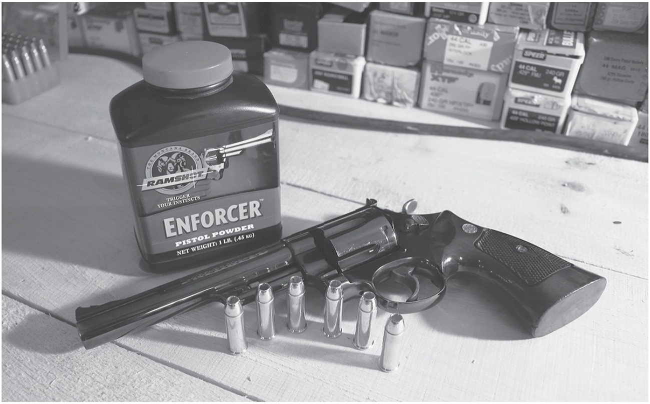
I found out early on that nickel-plated cases show a change in point of impact when compared to brass cases, even if from the same manufacturer. I ran into this first when loading for my .300 Winchester Magnum before a caribou hunt. That particular rifle had given me very good accuracy over the years, so I was a bit confused when the rifle printed a ¾-inch group, but three inches high and right. At first, I simply figured the scope had been bumped, but I grabbed three rounds of brass-cased ammo to double check. That stuff drilled the bull, so there

was nothing wrong with the scope. Three more nickel-cased rounds grouped where the first three had gone. I think that the nickel coating slightly reduced the case capacity, and increased the pressure and velocity, while still giving good accuracy.

I've had other instances where the nickel cases completely changed the accuracy of a rifle. My Legendary Arms Works Big Five rifle, chambered in .404 Jeffery, likes a particular load of Alliant's Reloder 15, printing three 400-grain Hornady DGX bullets into a 1.5-inch group at 100 yards when using Norma

brass. That same load, in Nosler nickel-plated cases, opened up to 4 inches, which is completely unacceptable. Now, that’s not to say that the Nosler cases are bad, but does demonstrate that the load would need to be revised if I were to use that type of brass. Very small variations in case volume can dramatically affect downrange accuracy and you should do your best to keep things as uniform as possible.

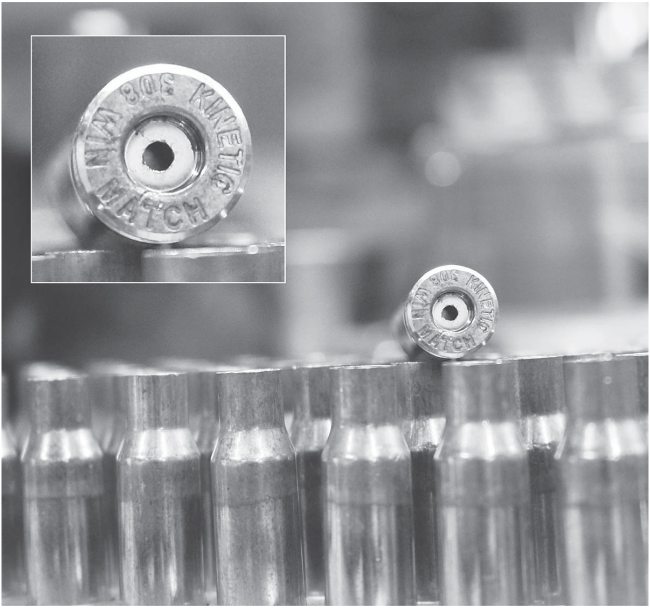
Straight-walled rimless cartridges need a taper crimp instead of a roll crimp.



A proper crimp on a .44 Magnum cartridge.

Again, when shooting factory ammo, you are at the mercy of the company that

loaded it, but through reloading can control many of the variables that affect both interior and exterior ballistics.



Traditional Boxer-primed cartridge.

TO CRIMP OR NOT TO CRIMP?

I’m sure you’ve run across some ammunition where you’ve seen the very end of the case mouth rolled around a groove in the bullet. This is roll-crimping, a process designed to firmly hold the bullet in place, and in some instances, provide a bit of resistance to generate pressures. This is especially prevalent in straight-walled rifle and revolver cartridges. It works for any cartridge that doesn’t use a square case mouth for headspacing, as do many pistol cartridges. In the instance of the rimless pistol cases, like the 9mm Luger, .40

Smith & Wesson, and .45 ACP (among others), the case mouth must not be rolled over, as it's used to properly headspace the ammunition; instead, a taper crimp must be employed. Taper crimping involves squeezing the sidewalls of the case tightly around the bullet to prevent it from moving in or out of the cartridge case during the violent chambering operation of an autoloading pistol.

There are instances where you may see a bottlenecked rifle cartridge use a roll crimp, and that's fine, as long as you're consistent. Personally, if the case has

enough neck tension to properly hold a bullet in the case, I generally don't crimp, as it really works the brass case and diminishes the amount of times it can be reloaded. But, for our purposes here, know that a heavy roll crimp can and will increase pressure, so observe your factory ammo to make sure things are consistent. If you're rolling your own, make a decision whether to crimp or not, and stick with it.

As an example, when making .44 Magnum ammunition I've seen a crimp die come out of adjustment and put a

very heavy crimp on the case mouth. This became painfully evident when the revolver was putting bullets all over the target. We inspected the ammo, and made a correction, and the Model 29 was back delivering the fantastic groups we knew it was capable of producing. There is a delicate balance between enough crimp to prevent the projectile from extending out of the case mouth (and preventing the cylinder from spinning), and excessive crimp that creates a pressure issue.

Indeed, the form and style of the cartridge case will affect performance

once things get ignited.

FLASH HOLES: BOXER V. BERDAN

Almost all American ammunition uses a centralized flash hole, or what we refer to as a ‘Boxer’ cartridge. You’ll find some European cartridges that use an offset, multi-holed design to deliver the spark into the powder charge, known as a ‘Berdan’ cartridge. While it really doesn’t matter to a shooter who uses only factory ammunition, it is of particular importance to reloaders, as the Boxer cartridge is easily reloadable, yet the Berdan

configuration is a much more difficult matter. Ironically, the Boxer design is a European development, while the Berdan hails from America. It is a mystery how things seem to have gotten switched around.

Berdan primer flash hole.

CHAPTER 3
THE PROJECTILE

That small blob of metal we call the bullet gets so little of the glory, yet does such a huge percentage of the work. Whether it's a round lead ball like those used by our forefathers, a cup-and-core jacketed bullet, or a monometal design that seems futuristic, the bullet — and only the bullet — is what gets the job done, ultimately. There are a multitude of

designs and construction methods, some of which have a definite effect on interior ballistics and play a role in the way your chosen cartridge performs within the bounds of the firearm.

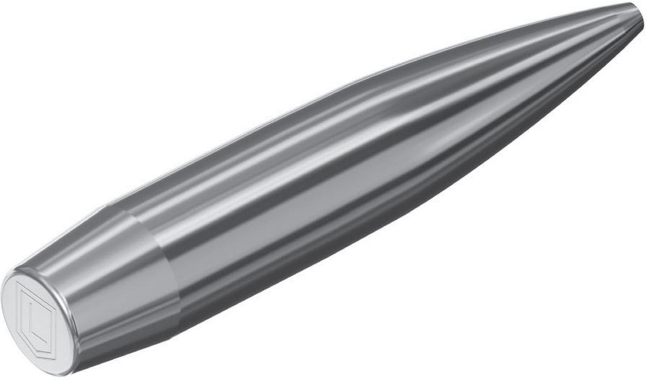
Let’s look at a couple of terms that will be important to us as we examine these projectiles. Firstly, we need to know a bullet’s *sectional density*, or SD. The sectional density of a bullet is nothing more, and nothing less, than a mathematical figure that represents the ratio of a bullet’s weight to its diameter. The actual formula is this: The bullet’s

weight (in pounds) is divided by the bullet's diameter (in inches) squared.

SD=Bullet weight in pounds ÷ Bullet diameter in inches^2

Since bullets are measured in grains, you need to convert to pounds by dividing by 7,000, as there are 7,000 grains in a pound. For example, to derive the sectional density of a .308 caliber 180-grain projectile, divide 180 by 7,000, yielding a weight in pounds of 0.02571. Then square the diameter of 0.308 to get

a figure of 0.09486. Divide the first figure by the second to arrive at a sectional density figure of 0.27103 or, as it is commonly represented out to three decimal places, 0.271. This figure has a large effect on the exterior and terminal phases of the bullet’s flight, and relevancy in correlating the length of a bullet to its diameter as we look at the amount of bearing surface that will be engaging the rifling. Of course, at that point in time the design of the bullet comes into play, thus understanding sectional density is important.



These .308 caliber bullets — 150 grains on the left, 180 on the right – clearly demonstrate the difference in sectional density.

Secondly, every bullet has a ballistic coefficient, or BC. This is a mathematical figure used to describe how well a bullet will resist atmospheric drag and the effects of crosswind. It is a figure typically represented by a decimal less than one, but in extreme cases above one, that represents a comparison to one or more standard bullet models. Ballistic coefficient, generally speaking, is the ratio of a bullet’s sectional density to its ‘coefficient of form.’ This math is long and drawn out, and will come into play much more once our metallic hero leaves

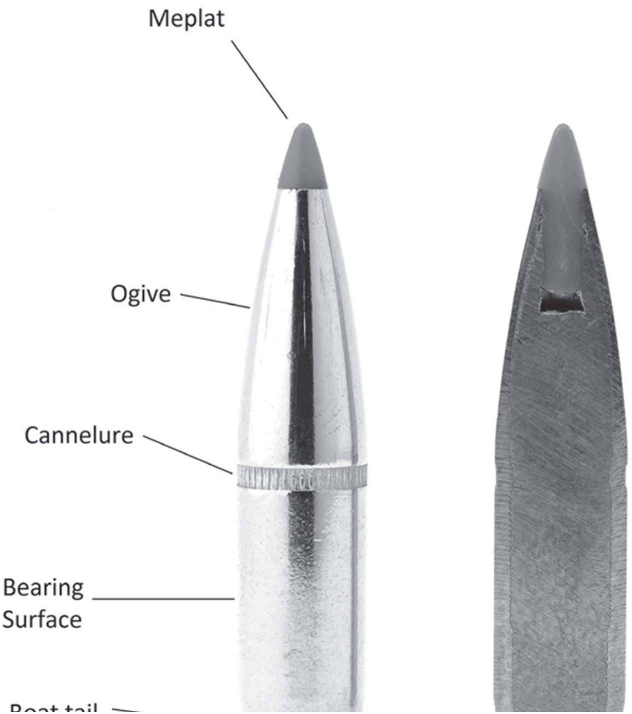
the muzzle, but for most applications the listed BC will suffice.

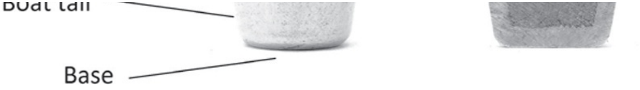
ANATOMY OF A BULLET

You should become familiar with bullet design, so you can understand which parts make a difference in performance once they are put into action. A bullet’s nose — or *meplat*, (pronounced *mee-plah*), French for ‘flat’ — comes in a variety of designs: pointed, round, flat, hollow, etc. The ogive of the bullet is the transitionary section where the meplat turns into the bearing surface at caliber dimension. Sometimes the

ogive is a straight line, as in the case of a truncated cone pistol bullet, but most often it’s a curve of some sort. The bullet’s bearing surface, or ‘shank’ is comprised of two parallel sides at specific caliber dimension, and it is this section of the projectile that engages the rifling of the barrel. The heel and base of the bullet finish out the design, and can range from a square, flat arrangement, to one of the sleek, tapered boat tail designs that will resist atmospheric interference best. Knowing the anatomy allows you to

choose which type of bullet will work best for your particular shooting needs.





A modern spitzer boat tail bullet.

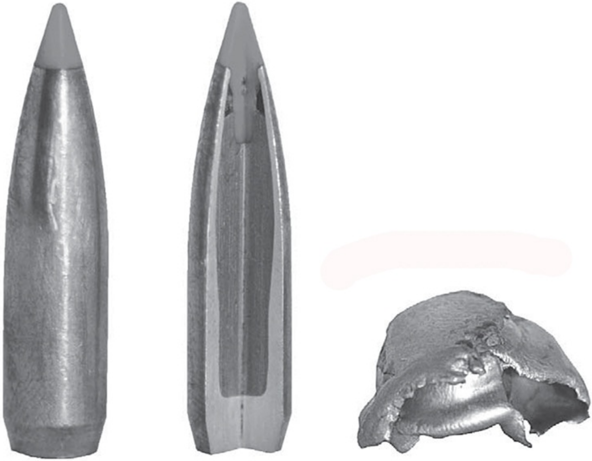
A round-nose, flat-based bullet.

THE CONSTRUCTION ZONE

A bullet’s makeup will definitely affect its ability to perform. And its construction is an important factor when considering interior ballistics. For example, a hardcast lead bullet can be pushed to a velocity of around 1,800 fps before things start to fall apart; the lead isn’t hard enough to take the rifling and spin at that rate, so it sort of skids down the barrel. Performance becomes erratic, and the smeared lead in your bore becomes an issue quickly.

Put a copper jacket around that lead bullet, and you can increase velocity dramatically. Yes, I’ve seen some copper cup lead-core projectiles come apart from extremely high muzzle velocities (we couldn’t figure out why the bullets weren’t hitting the 100-yard target, until we saw the bark missing on a tree 15 yards down range) but they are rather strong and can handle most sane velocities. Copper is a harder material than lead, yet is still soft enough to allow the steel rifling to impart the proper spin on the bullet. A copper jacket, or cup,

also helps to slow down expansion upon impact, but that’s to be discussed in the terminal ballistics section. What we are concerned about here is that a jacketed bullet, or as I prefer to call them a ‘cup-and-core bullet,’ can withstand much higher velocities than a lead bullet.



The Nosler Ballistic Tip, a modern cup-and-core bullet design, using a polymer tip.

North Fork premium bullets.

Should that cup-and-core bullet have its core chemically bonded to the jacket, all the better. Should it be an all-copper monometal design, there’s even less

worry of jacket separation, because there is no jacket to separate during the trip down the barrel.

THE SHAPES OF THINGS

Form is extremely important when considering interior ballistics. The bullet's shape will definitely affect the amount of pressure built, the way it engages the rifling in the throat section of the barrel, and how the bullet will feed from a magazine. There are a multitude of profile shapes when it comes to today's bullets. And these profiles will come into play with regard to interior and

exterior ballistics. There are models, set as the benchmark standards, which will be used to describe the bullet in flight. However, even before unguided flight begins (read ‘in the barrel,’ or interior ballistics), these standard shapes will give an idea as to how things will go.

Let’s take a look at some of the popular bullet profiles so we can identify and get a feel for their effects. That way, we’ll be familiar with them for all phases of the shot.

ROUND NOSE

Round-nose bullets are aptly named, for they feature a round (hemispherical) or rounded nose profile. Almost all round-nose bullets are flat-based, meaning the shank of the bullet meets the base at a right angle. This style of bullet is popular in auto-loading pistols and big-bore safari rifles, as the nose profile isn’t exactly the best for retaining energy and velocity at longer ranges, but feeds very well and hits with authority.

FLAT NOSE

Flat-nose bullets are defined by a flat, blunted meplat. They work very well in

most handguns as their effective range tends to be short (in relation to the high-powered rifles). This style of bullet is also popular in many of the lever-action rifles with tubular magazines, as the flat point eliminates the possibility of a magazine detonation caused by a pointed bullet striking the primer of the cartridge in front of it. Again, many of the lever guns are short to mid-range affairs, so there isn't a huge limiting factor with a flat-nosed bullet.

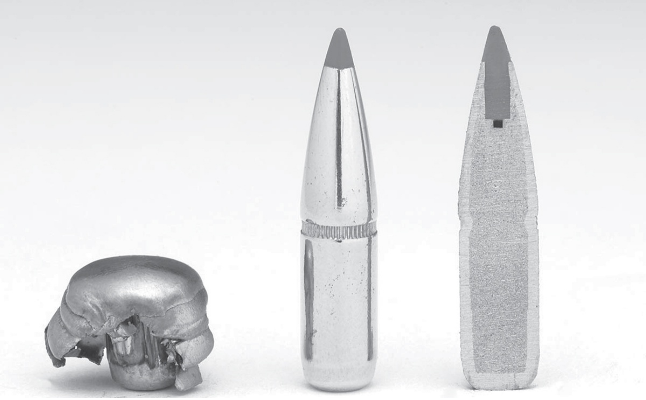
SPITZER

Derived from the German word *spitzgeschoss* — literally meaning ‘pointed projectile’— spritzers have a flat base with a nose profile that terminates in a pointed end; the transition from the shank or bearing surface to the end is a curve. Such bullets were one of the first designs that attempted to maximize velocity and energy figures. The spitzer design will cut through the atmosphere much more efficiently than will a flat- or round-nose projectile. While there are some spitzer bullets designed to be used in the larger bore revolvers, spitzers are

generally reserved for rifles.

These bullets are 200-grain flat points in .348 Winchester.

A round-nose Woodleigh Weldcore in the .318 Westley Richards.



Hornady SST bullet is a spitzer boat tail.

The Sierra-tipped MatchKing boat tail.

The truncated cone projectile.

BOAT TAIL

Ballistic experiments dating back to the end of the 19th century observed that a spitzer bullet's effectiveness improves

when used in conjunction with a boat tail, which allows the air to flow more easily around the bullet in flight. Used primarily in conjunction with a spitzer nose profile (though Peregrine Bullets from South Africa makes some excellent dangerous game flat-nosed bullets that use a boat tail) to make the ultimate aerodynamic design, the spitzer boat tail is highly popular with the long-range target and hunting crowd.

TRUNCATED CONE

Self-defining, the truncated cone bullet uses an ogive profile that doesn’t curve,

but features the straight line of a cone, terminating in a flat meplat, hence truncated. These bullets are popular in pistol cartridges, as well as in cast lead bullets for rifles. They work well in that all lead configuration, as well as the full metal jacket style.

Falcon Bullets truncated cone projectiles for the .45ACP.

WADCUTTER

Wadcutters are a purely cylindrical bullet, being square at the ends, and are

designed for cutting perfect holes in paper targets. The wadcutters score targets very easily. They are rather inexpensive and among the simplest to produce. Typically reserved for revolvers, these square-nosed bullets don’t really feed well in any of the autoloaders, but work just fine in a revolver’s cylinder. The wadcutter is sometimes employed as a defensive bullet style, giving all sorts of frontal diameter, yet not diminishing exterior ballistics when used in short-barreled revolvers like my sweetheart

Smith & Wesson Model 36 in .38 Special.

SEMI-WADCUTTER

Blending the simplicity of the wadcutter design with a truncated cone or a slightly curved ogive, semi-wadcutters make a good choice for an all-around bullet for handgun hunters and shooters. The famous ‘Keith’ bullet, which was popularized by gun writer Elmer Keith, features a flat nose of 70 percent caliber dimension, and a curved ogive — in order to keep the bullet’s weight forward — meeting almost all the requirements

for an all-around bullet for the target shooter, hunter and plinker alike. I’ve seen these bullets perform very well in revolvers and autoloaders, as well as rifles and carbines that were chambered for pistol cartridges.

Wadcutters are great for making a perfect hole in paper targets.

Hollowpoint bullets are extremely popular in modern handgun cartridges.

HOLLOWPOINT

The idea of reducing weight by hollowing out the nose portion of the bullet, which also enhances expansion, dates back to the 19th century, and still holds water today. The hollowpoint bullet is a staple in the industry in both pistol and rifle communities, for equally different reasons. The handgun folks truly appreciate and rely upon the radical expansion and threat-stopping capabilities of the hollowpoint pistol bullet, as do varmint hunters looking to create the ‘red mist,’ while the rifle target

crowd absolutely loves the accuracy and aerodynamics of the hollowpoint spitzer boat tails. Whichever feature you employ or enjoy, the hollowpoint bullet is one that is here to stay. For one thing, it gives great expansion for good terminal ballistics, and is among the most accurate designs available. I suppose you could include the polymer-tipped bullets in this group, as the general gist is that the hollowpoint has been filled with a polymer tip (both to increase the ballistic coefficient and to initiate expansion) yet the goal still remains the same: to provide

accurate, precise shot placement, and generate all sorts of expansion.

Comparing and contrasting these bullet profiles will demonstrate the different applications for the various types. There is a tool for every job, and a job for every tool. Each design has its advantages and its weaknesses, and depending on your shooting requirements, you may choose to employ several, if not all of these designs.

Take for example a bullet that’s .308 caliber, 180 grains, with a flat base and a round-nose design. If you were to

compare it to a flat-base, spitzer design, you could easy see how and why there would be a bit less bearing surface on the sharp bullet. Afterall, the bullet needs to interrupt the bearing surface to make room for the long, sharp nose. Again, look at a spitzer bullet, but this time put a boat tail on it, and you can see how the bearing surface (that portion of the bullet which engages the rifling) is further reduced based on the design itself, in turn affecting the pressure data.

Even closer scrutiny will reveal that when looking at the most aerodynamic

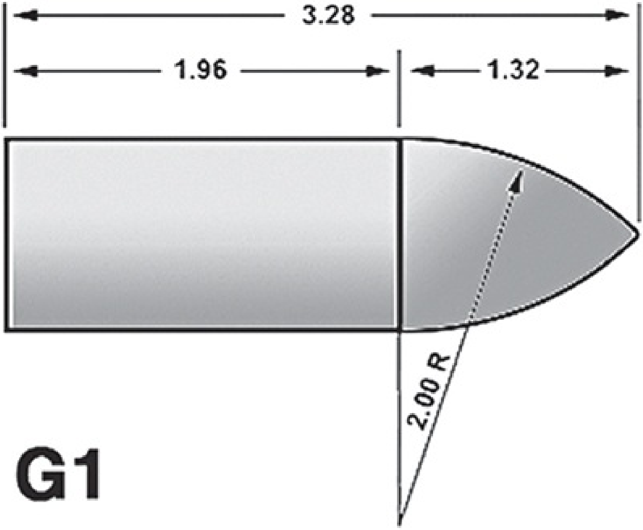
designs — bullets scientifically engineered to provide the least amount of air drag possible — you'll find that the nose profile curve that gives the least resistance may not be the profile curve that behaves the best between chamber and muzzle. So, you need a balance of performance between interior and exterior ballistics. In other words, it's no good having a bullet that defies the effects of gravity and wind drift if it doesn't give repeatable results (accuracy) that allows the shooter to actually hit the target.

When you look at those models or benchmarks that verily define ballistic capability, and compare them with the projectiles available for the calibers and cartridges you own, it will help you make an educated decision regarding the range of projectiles for your hunting and shooting applications. These models are known commonly as the G1 and G7 models; G1 being a flat-base spitzer bullet, while the G7 is a more modern, sleek design that correlates to the latest developments in bullet technology. It’s like comparing a Ferrari coupe to a box

truck. One would yield one set of data, which would seem radically impressive, yet if we put that Ferrari in its own class — say compare it to the Corvette design — the discrepancy won't be so dramatic, but will be much more accurately represented.

You'll find that most bullet companies tend to reference the G1 model; it's universal and easily understood. That model, when used as a reference, yields impressive figures that work well in the marketing department. Any which way you want to slice it, when you compare

these benchmark figures to the bullet you’re using, it will indeed give you a feel for both interior and exterior ballistics. Longer bullets with better BC figures invariably take up more space in a cartridge case with a SAAMI-specified overall length dimension. That factor will ‘eat up’ case capacity, and needs to be balanced out when it comes to manageable pressures.

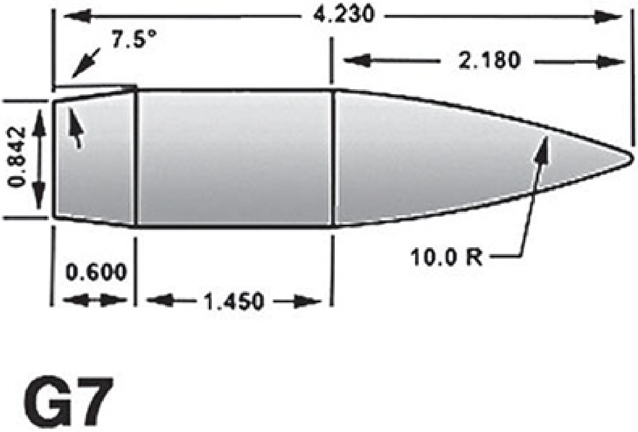


The G1 bullet model, the most popular model for ballistic coefficient comparisons.

However, longer bullets give a desirable effect once they leave the

barrel, but that’s for later. In the interior ballistics world, the longer, sleeker bullets come with a particular set of issues that should be understood. The ogive of such bullets, for reasons we will be examining in the exterior ballistics section, is typically of a secant curve profile, instead of the tangent ogive of the G1 model. Such are known as VLD, or Very Low Drag bullets. While VLDs fly through air better than their tangent curve counterparts, they don’t engage the rifling as well. Berger’s Hybrid line of bullets, designed by ballistician Bryan

Litz, use a blend of secant curve from the nose through a good portion of the ogive, yet transition into a tangent curve to best guide the bullet into the throat of the barrel.



The G7 bullet model, a better representation of modern, boat tail spitzer bullets.

Varying boat tail angles.

The same thing can be said for the boat tail angle of the bullet. Looking at the interior section of the bullet’s path, a boat tail has a base that is a measurable

dimension smaller than caliber, and the burning gas from the powder charge surrounds the base of the bullet up to the bearing surface. If, as I’ve had happen in some of my rifles, this gas doesn’t exit equally around the muzzle or crown of the barrel, accuracy can be affected. Should the crown be imperfect, gas will escape faster on one edge of the circle than the others and you’ll see inaccurate results in as little as 100 yards. It’s certainly not the boat tail bullet’s fault, and these symptoms can actually be masked by a flat-based bullet. However,

as in the case of my Ruger .22-250, a re-crown will solve the problem.

As the boat tail angle becomes steeper, the internal problem can get magnified; just as well as the benefits can be magnified on the opposite end of the muzzle. Again, while the long-range shooting crowd relies on a low drag, steeply boat-tailed bullet to flatten trajectory and retain velocity, it does come with a set of issues that must be dealt with in order to make things work properly.

This is the very dilemma that many hunters will face: while the long-range style bullet certainly shines for shots out past 300 yards, sometimes a flat-base bullet would better serve your needs, especially in the hunting fields. Again, a tool for every job, and a job for every tool. I like a flat-base bullet, which will seal the gas best and keep things as equal as possible, for shots within 300 yards; this comprises about 95 percent of my hunting shots. For my long-range work, I totally rely on the multitude of spitzer boat tails to make things go easier.

INTERIOR BALLISTICS OF PISTOLS

Autoloading pistols are a huge share of the market today, and with good reason: they deliver the goods. However, there are certain projectiles that preclude the smooth operation of an autoloading pistol. While I can easily use a wadcutter in my Smith & Wesson revolver, they just don’t work well in an autoloader. I sat down with my friend and colleague Marty Groppi, who knows what makes a 1911 tick, and discussed some of the problems associated with the feeding of

certain ammunition. See sidebar for his description of how to solve some of the issues with the feeding of anything other than round-nose or hollowpoint ammunition.

PRACTICAL BALLISTICS: SOLVING 1911 FEEDING ISSUES

By Marty Groppi

John Browning’s 1911 design has stood the test of time. After more than a hundred years, it’s considered to be among the finest autoloading pistols ever made. However, one of the

biggest complaints I hear from people is that their 1911 has feeding problems.

A classic 1911 and a modern rendition.

While this is a very frequent problem, it is not a fault of the pistol. The handgun was originally designed to shoot 230-grain round-nosed bullets, which tend to feed much easier than hollowpoints or semi-wadcutter loads. Now, to correct this problem, there are some very simple ‘do-it-yourself’ ideas that can solve this dilemma.

First and foremost, don’t change any angles in the feed ramp area. Not all 1911s have the same geometry. While polishing the feed ramp to

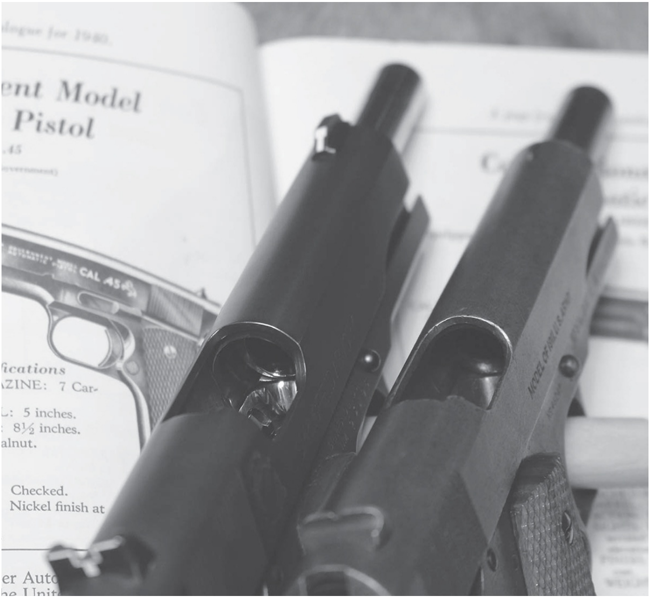
match your barrel, never take off enough material to change your feed angle. However, polishing the inside of the 1911 is a simple process that drastically improves its reliability. First, get a Dremel tool with some small polishing wheels, usually a kit that contains different sizes and shapes. Next, you’re going to need a polishing compound like Flitz, which isn’t too aggressive and leaves a nice finish. With your gun disassembled, start the polishing process of your feed ramp. Use low speed with the

Dremel tool and extreme caution as to not touch the sides. Polish the bottom of the barrel (at the angle) to make this section match the ramp in the frame of the gun. The main goal here should be polishing so that the feed ramp of the frame matches the barrel in a smooth transition. Many pistols have imperfections in the feed ramps or machining marks that make this angle unsmooth for feeding purposes. Polish these two parts until they have a mirror finish and feel as though they are one piece. Continue

until the bullet meets no resistance while feeding into the chamber.

Truncated cone and semi-wadcutter bullets can pose a problem in the 1911 platform, sometimes they just won’t feed.

The 230-grain round-nose design that works perfect in the 1911.



The polished interior (left) vs. untouched (right).

To make 1911s digest light loads, change out recoil springs. The average spring weight of the 1911 is around 16 pounds from the factory. This weight is meant for the 230-grain round-nose factory ammunition. There is no one set spring weight as to one specific handload. All 1911’s are different — whether it’s the differing material from which they are made or the size of the slide — which affects the weight of the slide. There is also the weight of the mainspring, another variant that can affect the

resistance met with the slide going from ‘in battery’ (the slide all the way forward) to all the way back (full recoil stroke). The power of your load is the main factor in your choice of recoil spring. Don’t go too light on your recoil spring. I have seen damaged guns due to people using too light of a recoil spring. When this happens, you get battering on the recoil stroke, damaging the gun. An easy way to set recoil spring weight goes as follows: first, make sure extractor tension is correct. Then try different

springs starting at the highest weight. If your gun is ejecting brass more than five or six feet, then you need a stronger spring. If your slide is recoiling so slowly that you’re having feeding/ejection problems, or the brass barely makes it out of the pistol, go with a lighter spring. I always use the heaviest recoil spring I can, with the gun still functioning correctly. When too light of a spring is used there is more felt recoil and you risk damaging your gun.

An untouched feed ramp.

Feed ramp after a good polishing.

A good magazine spring is a definite requirement.

Ballistics on light plinking loads vary, but almost all reloading manuals

will have the information needed to produce them. One thing to always remember: never drop below published data on your powder charge. If it is too low, pressure increases the same as if you overcharged the load. Always stay within the published data from your reloading manuals. On the other end of the spectrum, there are times you might want to increase the power of these ‘light loads.’ Most organized shooting matches have minimum loads that must be met to keep

competitors even. The term ‘PF’ refers to Power Factor, a measurement of energy. The procedure for determining the ‘PF’ for any load is a simple mathematical formula: Multiply the bullet weight (grains) by its velocity (fps) and divide the resulting figure by 1,000.

Power Factor= (Bullet weight x velocity)/1,000

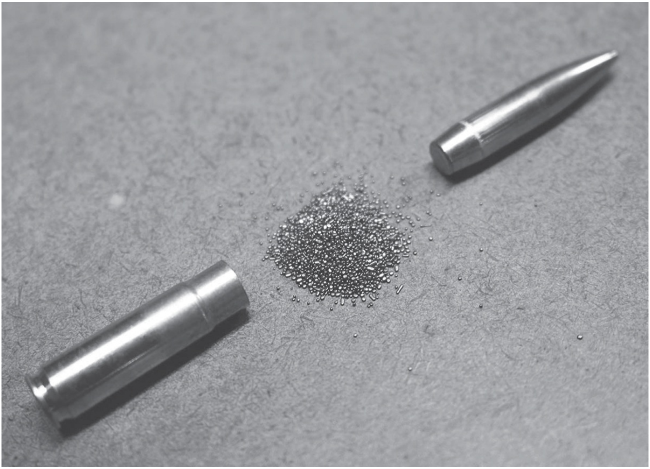
Be sure to check your magazine springs. More than half of the guns that have feeding problems can be corrected by either a mag

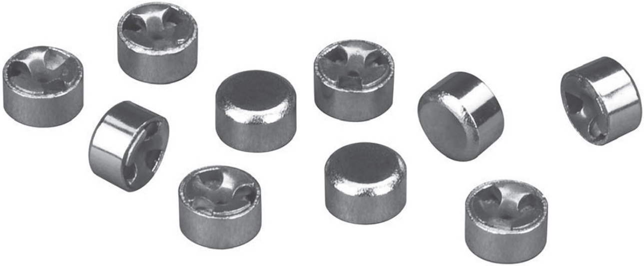
replacement or just changing out the springs with a simple Wolff +10 spring. These are just a few simple tricks to help your 1911 run smoother and aid in reliability. – Marty Groppi.

CHAPTER 4
THE IGNITION SYSTEM

The spark and fuel system of a cartridge case can make or break accuracy. The primers and powders of today are the most reliable and consistent we shooters have ever had. The primer, seated in the center of the cartridge case head of centerfire cartridges, or in the case rim of rimfire cartridges, uses a chemical compound that delivers a

shower of sparks through the flash hole when struck by the firing pin.





Large rifle primers.

PRIMER STYLES

There are two types of centerfire primers for our purposes: rifle primers and pistol primers. Each variety comes in large and small sizes and each size has a hotter spark “magnum” variant. Rifle primers have a thicker metal cup due to

the higher pressures at which they operate. Pistols operate at much lower pressures and therefore the primer cups are thinner. Large rifle and large pistol primers are 0.210 inches in diameter, while small rifle and small pistol primers are 0.175 inches. I’ve heard the myth of a “medium” primer, made by the Frankfort Arsenal in Pennsylvania, which is said to measure 0.204 inches, but I’ve never seen one with my own eyes. Col. Townsend Whelen refers to these being used in the early .45ACP cartridges, but for our purposes they are a moot point.

A large rifle magnum primer in the case head of a .375 H&H Magnum.

A variety of primers.

The designation of primers can be confusing. If you handload your ammunition, you must make a habit of checking and double checking your reloading manual so you have the right ones for the ammunition you are loading. Here are some examples of primer nomenclature:

- Large Rifle: CCI 200, Federal 210, Remington 9 ½, Winchester WLR
- Large Rifle Magnum: CCI 250, Federal 215, Remington 9 ½ M, Winchester WLRM

- Small Rifle: CCI 400, Federal 205, Remington 6 ½,
  Winchester WSR
- Small Rifle Magnum: CCI 450, Federal 250M, Remington 7 ½
- Large Pistol: CCI 300, Federal 150, Remington 2 ½,
  Winchester WLP,
- Large Pistol Magnum: CCI 350, Federal 155, Winchester WLPM
- Small Pistol: CCI 500, Federal 100, Remington 1 ½,
  Winchester WSP

- Small Pistol Magnum: CCI 550, Federal 200, Remington 5 ½, Winchester WSPM

There are also several varieties of match primers available, giving the most consistent results, which are readily embraced by the target shooting community. For example, the Federal 210 Large Rifle primer is available in match form, as the GM210M, or Gold Medal 210 Match primer. Several companies produce “military primers,” which have the thickest cups; these are designed for use in the AR platform and other

military-type rifles, and are made to military specifications. The CCI 34 (large rifle) and CCI 41 (small rifle) are two examples. These primers are designed to avoid a “slam fire” infrequently associated with the protruding firing pins found on some military firearms.

As mentioned, always use the type of primer called for in the reloading manual you are using, as a change in primers can result in a change in pressure. It is also a good idea to have only one type of primer on your reloading bench at one time to

avoid any confusion and a possibly dangerous situation at the bench.

So, these little wonders are the first spark in the chain of combustion events that cause a bullet to be launched. The spark is created by the reaction of lead, barium nitrate and other chemical compounds being struck against the anvil located in the primer cup. This explosion sends sparks through the flash hole and into the powder charge. The first percussion cap used in the muzzleloading rifles of the mid-19th century needed to be struck against an anvil, in this case the

nipple on the percussion lock. The modern configuration of primers for centerfire cartridges feature a self-contained anvil within the primer assembly. Years ago, the priming compound contained fulminate of mercury, a corrosive substance.

Care must be taken when firing old (WWII-era or earlier) military ammunition. While commercial sporting ammunition made the switch to non-mercuric primers around the turn of the 20th century, the U.S. military did not make the official switch until after the

Second World War. If you use this type of ammunition, be sure to clean your rifle with a good solvent after shooting it. When my pal Kevin Hicks first bought his sweetheart .30-06, we had a surplus of WWII military ammunition on hand for practice and sighting in. After taking the rifle to the range, he decided to clean it several days later. He could barely fit a patch down the bore because of the corrosion caused by those old primers. Hours of scrubbing and brushing later, he had things back in order, but it was a nasty chore, and he was concerned about

the condition of the bore. That was the last time we shot them without cleaning immediately! Thankfully, today’s primers are non-corrosive.

Primer sealant on a Federal .45-70 Government cartridge.

Certain types of factory ammunition — Federal comes quickly to mind — use a primer sealant to prevent any moisture from making its way into the combustion chamber. While it certainly doesn't hurt, I've never personally used a sealant on any of my ammo, and (knock on wood) I've never had any issues.

POWDER, THE FUEL SYSTEM

The burning powder charge is what generates the pressure that drives your bullet out of the cartridge case and down the barrel. The smell of burning powder

is among my favorite scents; it brings me back to my youth, spending time with my father, learning to shoot. In order to better understand how the different types of powder affect the performance of your firearm let’s look at the history of this amazing stuff.

Friar Roger Bacon was the first European to record the mixture for gunpowder in the 13th century, although it is a widely held belief that Chinese culture had it long before that. Regardless, that blissful blend of Sulphur, charcoal and saltpeter called black

powder certainly changed the world. It ruined the effectiveness of metal armor, diminished the security of the castle, and leveled the playing field between strong, brave soldiers and their more diminutive counterparts.

Black powder has not really changed in its makeup over the last century and is still going strong. However, it burns dirty and leaves a corrosive residue throughout the bore, which must be removed quickly to prevent rusting and pitting. There are cleaner burning substitutes available that have made the job of cleanup easier.

Blackhorn 209, as well as Hodgdon’s Pyrodex and 777 are among these. Black powder is generally measured by volume, not weight, and the substitutes are measured this way as well. It’s graded and identified by the coarseness or fineness of the granules. Fg is the very coarse cannon and shotgun powder, FFg and FFFg are more fine and used in many rifles and pistols, and the finest, FFFFg is typically reserved for priming the flintlock action.

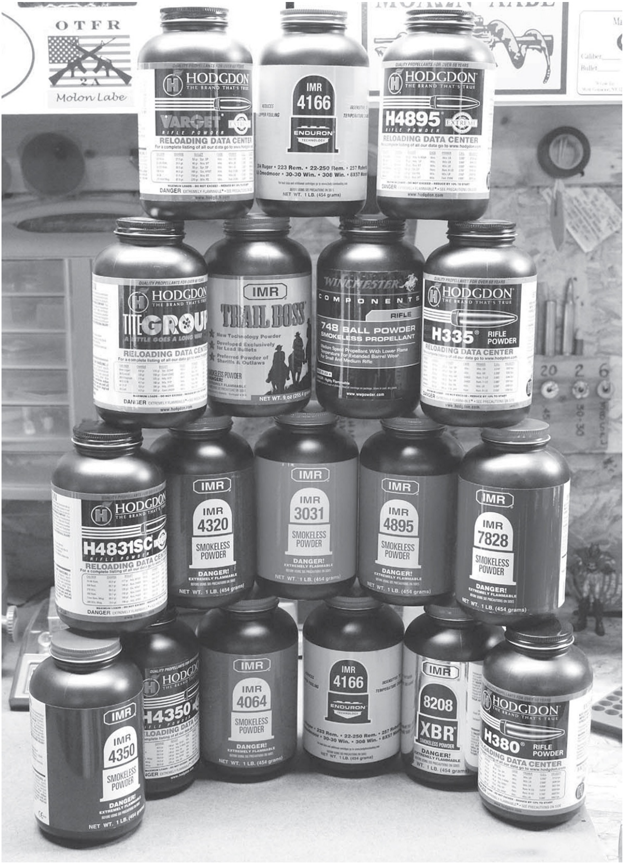
Progress was made in the scientific field of powder in the 1840s, when nitric

acid was put upon cellulose to produce nitrocellulose. This was known as gun cotton. It was capable of producing pressures and velocities much greater than black powder, and it took time to develop steel that could withstand the pressures generated. Later, in 1887, Alfred Nobel invented nitroglycerine. When mixed with nitrocellulose, this created a plasticized substance that was a stable compound. Cordite, an early British version, was the propellant du jour for many of our classic cartridges. One of cordite’s little peculiarities was

the fact that it was extremely sensitive to temperature fluctuation. Those cartridges that were developed in England and Continental Europe often had pressure increases when brought to steaming hot Africa and India. The heat of the Tropics quickly brought out the flaws of cordite, from extraction troubles to cracked receivers and this is why some of the huge cases like the .416 Rigby and the .470 Nitro Express came about. They needed that volume to keep the pressure low.

Modern single- and double-base smokeless powders have resolved that issue, and the temperature sensitivity has been diminished greatly. Single-base powders are comprised mostly of nitrocellulose; double-base of a mixture of nitrocellulose and nitroglycerine. The powder is coated with a deterrent and a stabilizer; the deterrent slows the burn rate to a desired amount, and the stabilizer slows down the self-decomposition of the compound. Taking things even further, Hodgdon — who produces smokeless powder under their

own brand, as well as IMR and Winchester — recently introduced the ‘Enduron’ line of powders, which have been engineered to provide very uniform burn rates to minimize the effects of temperature fluctuation upon muzzle velocities. I’ve used these powders in temperatures ranging from single digits, up to 112°F in Africa, and they’ve performed flawlessly.



OTFR
Molon Labe
HODGDON
THE BRAND THAT'S TRUE
VARGET
RELOADING DATA CENTER
IMR
4166
ENDURON
HODGDON
H4895
RELOADING DATA CENTER
HODGDON
TITEGROUP
RELOADING DATA CENTER
IMR
TRAIL BOSS
WINCHESTER
COMPONENTS
748 BALL POWDER
SMOKELESS PROPELLANT
HODGDON
H335 RIFLE POWDER
RELOADING DATA CENTER
HODGDON
H4831SC
RELOADING DATA CENTER
IMR 4320 SMOKELESS POWDER
IMR 3031 SMOKELESS POWDER
IMR 4895 SMOKELESS POWDER
IMR 7828 SMOKELESS POWDER
IMR 4350 SMOKELESS POWDER
HODGDON
H4350
IMR 4064 SMOKELESS POWDER
IMR 4166 ENDURON
IMR 8208 XBR
HODGDON
H380 RIFLE POWDER
RELOADING DATA CENTER

Smokeless powder.

POWDER STRUCTURES AND NOMENCLATURE

The shape of the powder granules can be one of three types — flake, stick and spherical. Flake powder is shaped like miniature pancakes. Many shotgun and pistol powders are in this configuration, and some contain color-coded flakes. Alliant’s Green-Dot, Bullseye and Unique are three examples of flake powder.

Stick powder is one of the most popular shapes in rifle propellant. The compound is extruded into long spaghetti-like rods, and cut to the desired length. Examples of stick powder include IMR4064, IMR4350, IMR4451, Hodgdon’s Varget and H4831SC, and Alliant Reloder 25.

Flake powder, Alliant's Unique.


IMR
4451
REDUCES
FOULING
ENDURON®
TECHNOLOGY
6 mm Rem. • 270 Win.
300 WSM • 338 Win. Mag
NET WT. 1 LB. (454 grams)

IMR 4451, a consistent-performing stick powder in the new Enduron line from Hodgdon.

Spherical powder is a round ball, or a slightly flattened round ball. It takes up less space than stick powder, and can help achieve good velocities in a case with limited capacity. Some of the spherical powders include Hodgdon's H380 and BL-C(2), Winchester's 760, and Accurate Powder's No. 9.

Powder is measured in *grains*, not to be confused with grams, a metric unit of weight. There are 7,000 grains to the

pound. Depending on the cartridge being loaded (and especially pistol cartridges) a variation of as little as 1/10th of a grain can make the difference between a safely loaded cartridge and a dangerous one that produces excessive pressures. IT IS IMPERATIVE THAT YOU STRICTLY ADHERE TO THE LOAD DATA PUBLISHED BY REPUTABLE MANUFACTURERS! I cannot stress that point enough. The various reloading manuals are a product of months or years of pressure testing under strict laboratory conditions, and an attempt to exceed the

published values can result in your untimely demise. Start at the published minimum charge weight, and carefully increase the charge, stopping when you see the first sign of excessive pressure.

The powders available to the handloader are referred to as “canister grade.” They are each unique in their burn rate. “Fast” burning powders are (generally) used in shotshells, small-case rifle cartridges and many of the pistol cartridges. The “medium” burn rate cartridges work well in the standard rifle cartridges and some of the bigger caliber

magnums. The newly developed slow-burning powders really shine in the huge overbore cases. Velocity kings like the .30-378 Weatherby, 7mm STW, .338 Remington Ultra Magnum and .338 Lapua all develop their high speeds from very slow-burning powders that develop the high pressure necessary to push bullets fast.

Today’s powders go by many different names, and it can be confusing, bordering upon dangerous. Some are just names like Bullseye, TiteGroup, Varget, Red Dot or Unique. Others are just numbers,

such as (Accurate Arms) No. 5, (Winchester) 760 and 748. Yet others still are a combination, such as IMR7828, H380, N160, Reloder 15, etc. It is important that you are well versed in powder nomenclature to avoid confusion and possible injury. An example: There are three different powders, from three different manufacturers that contain ‘4350’ in their name. IMR4350 (Improved Military Rifle), H4350 (Hodgdon) and AA4350 (Accurate Arms), and all have slightly different burn rates AND ARE NOT

INTERCHANGEABLE. Strict attention must be paid to ensure that you have the right powder called for by the reloading manual. This rule must be followed.

Hodgdon’s H380, a spherical powder that’s useful for cases with limited capacity.

Storing powder is not a big deal. Common sense should prevail. It should be stored in a cool place, with no risk of open flame and far away from children. I store my powder in a clearly labeled wooden box with a lockable lid. You never want to store it in a container that will contain pressure; in the event of a fire powder that is not under pressure will burn rapidly, but put it under pressure and you’ve made a bomb. A gun safe is the absolute wrong idea for storage. Always store powder in its original canister; never try to relabel another container. I

mark the date of purchase and the date I opened the canister, so I can use the powder in the order in which it was purchased.

Choosing a powder can be time-consuming. Often, reloading manuals will offer several selections per cartridge/bullet combination, sometimes highlighting or recommending the powder *that worked best in their test rifle or pistol*. All barrels are different, and while the most accurate load in the manual may work well in your firearm, sometimes you may need to experiment.

Not all manuals test every powder that would be suitable for your cartridge, so inevitably you will end up owning more than one manual.

Some powders can be used in many different applications. For example, among pistol cases, I use Unique and TiteGroup in many different cartridges, from 9mm Luger to .45 Long Colt. The .308 Winchester is the first cartridge I learned to reload. My Dad, Grumpy Pants, insisted that a 165-grain bullet on top of IMR4064 was the only way to go, and anything else was blasphemy. In his

world, at that time, there was no other powder, or cartridge for that matter. I have used IMR4064 (because we had a ton of it!) in .22-250 Remington, .243 Winchester, 6.5x55 Swedish, .270 Winchester, 7x57 Mauser, .308 Winchester, .30-06 Springfield, .300 Winchester Magnum, .375 H&H Magnum and my sweetheart .416 Remington Magnum. This doesn’t mean it’s the only powder that will work, nor the best powder in each of those cartridges. It just means that it is a

powder which has a wide range of applications.

Conversely, a single cartridge may be served well by a large number of different powders. The venerable .30-06 Springfield, that classic of classics, can be fed a wide range of powders, with innumerable burn rates, and still provide great results. For example, depending upon bullet weight, the following powders are well-suited for use in the .30-06: IMR3031, IMR4064, IMR4320, IMR4350, IMR4895, IMR 7828; Hodgdon VARGET, H414, H380, H4350

and BL-C(2); Alliant Reloder 15, Reloder 17, Reloder 19, Reloder 22, Reloder 25 and 4000-MR; Winchester 748, and 760, you get the idea. There are many like it. Read the manuals and choose wisely. It may take several attempts before you find that accuracy you so desire.

BURN RATES AND INTERIOR BALLISTICS

Not all gunpowder burns at the same rate. One quick glance at a burn rate chart will reveal that there are many different powders, for many different applications. Factory loaded ammunition may or may

not use a canister grade powder; some of the companies use a blend of powders to achieve higher velocities; this is something that reloaders must not do, as the factories have developed this practice under strict laboratory conditions, and any attempt at blending powder types by a reloader is begging disaster. The canister grade powders should suffice to achieve your goals. While it is often difficult to match or exceed the factory loaded ammunition’s velocities, the uniformity of handloaded ammunition can often lead to an increase in accuracy.

The large, fast cartridges — for example, the .30-378 Weatherby Magnum, .300 Remington Ultra Magnum and the 7mm STW — begin to shine when using the slowest burning powders, which generates the highest velocities. These cartridges will also perform best when using a longer barrel, say 26 inches or more, in order to burn as much of the huge powder charge as possible — generating the highest velocities for which they have been chosen. The term ‘overbore’ is used to describe a cartridge that may not be able to burn its powder

charge within a barrel length common to that cartridge. As an example, my pal Dave deMoulpied has a .257 Weatherby Magnum that will produce a visible flame at the muzzle of about 12 inches, even at noon on a sunny day. While the .257 Weatherby is certainly a flat-shooting, hard-hitting cartridge, the case may be classified as having a powder charge too large to be burned in the 26-inch barrel. That doesn’t make it a bad cartridge, but it’s fair to say that it isn’t one of the more efficient designs.

BURN RATE CHART

From fastest to slowest (some newer powders may not appear).

Ultimately, what you’re looking for from your firearm is accuracy, and accuracy is most definitely a product of uniformity. Taking the shooter out of the equation, I like my gear to operate as best as possible, making me the weak link in the chain. Accuracy is also obtained through repeatability, and that requires all things to be as equal as possible for every shot. Some of my most accurate rifles and ammunition have one thing in common: the muzzle velocities, when

measured with an accurate chronograph, have a very low standard deviation. For example, my Savage Model 116, chambered in 6.5-284 Norma, maintains ⅓MOA groups out to 500 yards. While this fact is certainly influenced by the fact the rifle is well-constructed, it is also due to the fact that the ammunition gives extremely uniform results. My Oehler Model 35P chronograph has shown that these loads give an extreme velocity spread of no more than 8 fps, up or down, from the average. Most of my accurate handloaded ammunition has

demonstrated the same trait, and I firmly believe there is a direct correlation between accuracy and uniform velocity, especially when the distance to the target increases. While some loads with a wider velocity spread may show more than acceptable accuracy at 100 yards, they tend to open up when you take things out to 300 yards and beyond. That 6.5-284 of mine likes several different bullets, but definitely shows a preference for Hodgdon H4831SC powder, which has a burn rate that works well in this case. I've tried other powders, and while I obtained

accurate results that were more than acceptable, H4831SC gave the best results by far; yet, in other 6.5-284 rifles, this particular load didn’t work nearly as well. Point is, each barrel is slightly different, and may react differently to a particular powder charge, playing a significant role in accuracy. If you don’t handload and use factory ammunition, you’ll have to experiment with many different brands until you find the combination of bullet and powder charge that will show the full potential of your rifle or handgun. You’ll see a particular

type of ammunition either praised as being ‘the best’ or slagged as being ‘terribly inaccurate’ on many Internet forums, but realize that more often than not all that’s represented is the experience of one shooter with one firearm. You may find an entirely different result in your gun.

Table 4-1

1	NORMA R1
2	Winchester WAALite
3	VihtaVuori N310
4	Accurate Arms Nitro 100
5	Alliant e3

6	Hodgdon TITEWAD
7	Ramshot Competition
8	Alliant Red Dot
9	Alliant Promo
10	Hodgdon CLAYS
11	Hodgdon Clay Dot
12	IMR, Co Hi-Skor 700-X
13	Alliant Bullseye
14	Hodgdon TITEGROUP
15	Alliant American Select
16	Accurate Arms Solo 1000
17	Alliant Green Dot
18	Winchester WST
19	IMR, Co Trial Boss
20	Winchester Super Handicap
21	Hodgdon INTERNATIONAL
22	Accurate Arms Solo 1250

23	IMR, Co PB
24	VihtaVuori N320
25	Accurate Arms No. 2
26	Ramshot Zip
27	IMR, Co SR 7625
28	Hodgdon HP-38
29	Winchester 231
30	Alliant 20/28
31	Alliant Unique
32	Hodgdon UNIVERSAL
33	Alliant Power Pistol
34	VihtaVuori N330
35	Alliant Herco
36	Winchester WSF
37	VihtaVuori N340
38	IMR, Co Hi-Skor 800-X
39	IMR, Co SR4756

40	Ramshot True Blue
41	Accurate Arms No. 5
42	Hodgdon HS-6
43	Winchester AutoComp
44	Ramshot Silhouette
45	VihtaVuori 3N37
46	VihtaVuori N350
47	Hodgdon HS-7
48	VihtaVuori 3N38
49	Alliant Blue Dot
50	Accurate Arms No. 7
51	Alliant Pro Reach
52	Hodgdon LONGSHOT
53	Alliant 410
54	Alliant 2400
55	Enforcer
56	Accurate Arms No. 9

57	Accurate Arms 4100
58	Alliant Steel
59	NORMA R123
60	VihtaVuori N110
61	Hodgdon LIL'GUN
62	Hodgdon H110
63	Winchester 296
64	IMR, Co IMR 4227
65	Hodgdon H4227
66	IMR, Co SR4759
67	Accurate Arms 5744
68	Accurate Arms 1680
69	NORMA 200
70	Alliant Reloder 7
71	IMR, Co IMR4198
72	Hodgdon H4198
73	VihtaVuori N120

74	Hodgdon H322
75	Accurate Arms 2015BR
76	Alliant Reloder 10X
77	VihtaVuori N130
78	IMR, Co IMR 3031
79	VihtaVuori N133
80	Hodgdon BENCHMARK
81	Hodgdon H335
82	Ramshot X-Terminator
83	Accurate Arms 2230
84	Accurate Arms 2460s
85	IMR, Co IMR 8208 XBR
86	Ramshot TAC
87	Hodgdon H4895
88	VihtaVuori N530
89	IMR, Co IMR4895
90	VihtaVuori N135

91	Alliant Reloder 12
92	Accurate Arms 2495BR
93	IMR, Co IMR 4064
94	NORMA 202
95	Accurate Arms 4064
96	Accurate Arms 2520
97	Alliant Reloder 15
98	VihtaVuori N140
99	Hodgdon VARGET
100	IMR, Co IMR4320
101	Winchester 748
102	Hodgdon BL-C(2)
103	Hodgdon H380
104	IMR, Co IMR 4007 SSC
105	Ramshot Big Game
106	VihtaVuori N540
107	Winchester 760

108	Hodgdon H414
109	VihtaVuori N150
110	Accurate Arms 2700
111	IMR, Co IMR4350
112	Hodgdon H4350
113	Alliant Reloder 17
114	Accurate Arms 4350
115	NORMA 204
116	Hodgdon HYBRID 100V
117	VihtaVuori N550
118	Alliant Reloder 19
119	IMR, Co IMR4831
120	Ramshot Hunter
121	Accurate Arms 3100
122	VihtaVuori N160
123	Hodgdon H4831 & H4831SC
124	Winchester Supreme 780

125	NORMA MRP
126	Alliant Reloder 22
127	VihtaVuori N560
128	VihtaVuori N165
129	IMR, Co IMR7828
130	Alliant Reloder 25
131	VihtaVuori N170
132	Accurate Arms Magpro
133	Hodgdon H1000
134	Ramshot Magnum
135	Hodgdon RETUMBO
136	VihtaVuori N570
137	Accurate Arms 8700
138	Hodgdon H870
139	VihtaVuori 24N41
140	Hodgdon H50BMG

141	Hodgdon US869
142	VihtaVuori 20N29

I’ve also seen shooters complain that something has gone terribly wrong with their firearm, because Brand X ammunition, loaded with a particular bullet, which has historically produced fantastic results, suddenly throws bullets all over the target. The problem didn’t lie with the firearm, or even the shooter; what happened was the Brand X Ammunition Company changed the powder type and/or load for that line of ammo, and the firearm didn’t shoot the

new load well. Many shooters, when they find a load that their rifle or handgun shoots well, will do their best to obtain as much of that ammo as possible, often trying to stay within the same lot number, to keep things as uniform as possible.

POWDER CHARGES: WEIGHT VS. VOLUME

There are a couple of ways to think about powder charges, and you'll see a dichotomy when you compare a serious handloader with a benchrest shooter. As a handloader, I was taught to weigh all of my powder charges to keep things as

uniform as possible. But many of the benchrest shooters who achieve fantastic accuracy load their powder by volume, not weight. Which is the better method? That depends. Again, experimentation is key, but if your firearm shows better accuracy with one method over another, go with it.

PISTOL CARTRIDGES AND POWDER CHARGES

Pistols can be a different animal altogether, especially since so many of their cases have a capacity which can hold a double charge of powder, and that

will result in terrible things happening. The progressive presses, which are highly efficient for those situations where you need a whole bunch of ammunition for pistol competitions, use a case-activated powder thrower to dispense powder into the newly resized case. Care must be taken to properly adjust the dispenser, due to the fact that pistol charges are relatively light, and an overcharge of 0.2 grains can result in excessive pressure. The common powders for pistols cartridges — including Bullseye, Unique, 700X and TiteGroup — all meter very

well, but again, it’s not easy to detect a slight overcharge that could cause trouble.

Of the powders experimented with in the 6.5-284 Norma, the author’s gun showed a definite preference for Hodgdon’s H4831SC. Yours may be different.

Some good pistol powders, yielding desired velocities for a hunting cartridge.

Most of the pistol powders are fast-burning, and generally use the flake or ball powder shape. This gives them lots of surface area for burning, and generates

a (generally) lower pressure, when compared to centerfire rifle cartridges. Things tend to get a bit slower burning when you get into the bigger revolver cartridges that are so popular among handgun hunters. The .44 Magnum, .45 Colt, and .454 Casull are all prime examples of great handgun hunting rounds, and while they will run on many of the standard powders, they really perform best with the slower powders that wrings that last bit of velocity from the big cases. Hodgdon’s H110, Ramshot’s Enforcer, and Accurate Arms

No. 9 will certainly fuel the fire, and when loaded behind a good premium bullet, deliver the goods on the hunting fields. Once again, a good reloading manual will give you a feel for what powder will work best in your cartridge.

CHAPTER 5
THE BARREL

The barrel is the rifle’s delivery system, the steel guidance mechanism that sends the projectile spinning toward the target. Barrel technology has come leaps and bounds in the last century, to the point where the accuracy has become both highly predictable, as well as repeatable. It’s important to know how barrels work, in order to better

understand how a bullet will perform within its confines.

THE THROAT

Starting at the breech end, your barrel has three or four main parts, depending on the type of firearm. For rifles, as well as semi-automatic pistols, there is a chamber, throat or leade, and the rifling itself, all terminating at the crown. The chamber is a mirror image of the cartridge to be fired, and is sealed by the breech bolt or block to ensure all the burning gas pushes things toward the muzzle end of the barrel. The throat, or

leade, is the area between the chamber of the barrel and the point where the rifling begins. The length of the throat can vary greatly, from less than 1/16th inch, to as much as ½ inch, depending on the cartridge and manufacturer. The throat is exposed to burning powder and hot gas, and when shooting a high-velocity cartridge is often the first part of the firearm to show wear and erosion. Some of the fastest cartridges, like the .300 Remington Ultra Magnum and .264 Winchester Magnum, can show throat wear in as little as 1,500 rounds. I make a

conscious effort not to heat my barrels excessively, to help keep wear and tear to a minimum. Some companies (Weatherby for example) purposely extend the throat of their barrels to give room for the bullet to jump. This is known as ‘free-bore,’ and can help increase accuracy. You never want a modern cartridge to have the projectile touching the rifling; dangerous pressures can easily develop. At the end of the throat, the rifling begins.

The .300 RUM can generate throat-burning velocities. The .264 Winchester Magnum can erode a throat rather quickly.

RIFLING

Rifling is the set of twisted ‘ridges’ you’ll see when you look down the bore of the firearm. It imparts a spin on the

bullet, keeping it stable in flight. Those ridges, properly called *lands*, engrave their imprint into your bullet, and are machined at a smaller diameter than the bullet itself. The corresponding valleys, or *grooves*, are designed to be at caliber dimension to properly seal the gas and build pressure. The number of lands and grooves can vary, from the “two-groove” U.S. Army Springfield rifles of the early 20th century, to the Marlin MicroGroove barrel that used 16 or more, and all sorts in between. (Note: some handgun companies today employ ‘polygonal

rifling,' which is a bit of a different geometry, yet works fine for their purposes.) Almost all common barrels use a static twist rate, meaning that the grooves are cut in a specific manner to maintain a consistent spin on the bullet. When researching rifles, note the barrel specs listed as 1:10, or 1:7 twist rate. This is simply a means of telling you how fast or slow the barrel will cause the bullet to spin. The example twist rates given above work like this: a barrel with a 1:10 twist rate will have a bore in which the lands make a complete revolution in 10 inches

of barrel (“one in ten”), while the 1:7 barrel will make that same complete revolution in just 7 inches of barrel, therefore imparting more spin on the bullet. The higher the sectional density figure of a particular bullet (read that as a longer bullet), the faster it must be spun in order to maintain gyroscopic stability throughout its flight. While the numbers may be deceiving, a 1:10 barrel is called a ‘slower’ twist than is 1:7, and with many of today’s bullets becoming longer and heavier for caliber, the fast twist rate

barrels are becoming more desirable to take advantage of these bullets.

Rifling in a .45 Colt barrel.

One of my favorite varmint rifles is a Ruger Model 77 MkII, chambered in .22-250 Remington. This big case is the old .250-3000 Savage necked down to hold .224-inch diameter bullets, and there is plenty of powder capacity to push the bullets to high velocity. However, because the .22-250 uses a relatively slow twist rate — either 1:12 or 1:14 — the heaviest bullet I can use in this rifle is a 55-grain slug. While there are plenty of good, heavy bullets for hunting and/or

target work available in this caliber right up to 80 grains and more, my rifle can't stabilize them with that slower twist rate. My dad's .223 Remington, with its 1:8 twist rate, can shoot most of the heavier designs without issue, even though it has much less case capacity. My .22-250 serves me well, and can really reach out and touch the coyotes and woodchucks, but I'd love to be able to utilize the longer bullets.

For years, I used a .308 Winchester exclusively as my big game rifle here in Upstate New York. I shot a .308 because

Dad shot a .308, and we always discussed the reasons that we couldn’t use the heavy, 220-grain round-nosed slugs common in the .30-06 Springfield. He insisted it was a case capacity issue, but I found out that the .308 Winchester was originally released with a 1:12 twist, as opposed to the Springfield’s 1:10, so it couldn’t stabilize bullets heavier than 200 grains. (The .30-06 Springfield, normally supplying a 1:10 twist, can stabilize the heavy 220-grain bullets, but the .308 Winchester with a 1:12 cannot.) To prove my point, I borrowed a .308 Winchester

with the faster twist rate, and loaded up some 220-grain pills. Much to my father's chagrin, they worked just fine.

Here's a chart of many common twist rates, from popular manufacturers. Of course, there may be some variations, but this should give you a good starting point.

COMMON TWIST RATES FOR RIFLE CALIBERS

Rifle Caliber Twist Rate

.17 Mach II 1:9	.250/3000 Savage 1:10, 1:14

.17 Hornady Magnum Rimfire 1:9	.25 WSSM 1:10
.17 Winchester Super Magnum 1:9	.257 Weatherby Magnum 1:9.5
.17 Hornet 1:9	.260 Remington 1:8, 1:9
.17 Remington 1.9	6.5 Grendel 1:8
.204 Ruger 1:12	6.5 Creedmoor 1:8
.22 Long Rifle 1:16	6.5x55 Swedish Mauser 1:7.5
.22 Winchester Magnum Rimfire 1:16	6.5-284 Norma 1:8, 1:9
.22 Hornet 1:14	.264 Winchester Magnum 1:8, 1:9
.222 Remington 1:14	.26 Nosler 1:8
.223 Remington 1:7, 1:8, 1:9, 1:12	6.5-300 Weatherby Magnum 1:8
.223 WSSM 1:10	.270 Winchester 1:10
.22-250 Remington 1:12, 1:14	.270 Winchester Short Magnum 1:10

.220 Swift 1:12, 1:14	.270 Weatherby Magnum 1:10
6mm Remington/.244 Rem. 1:9, 1:12	6.8 SPC 1:9.5, 1:11, 1:12
.243 Winchester 1:10	7x57 Mauser 1:8, 1:9, 1:10
.243 WSSM 1:10	7-30 Waters 1:9
.240 Weatherby Magnum 1:9.5	7mm-08 Remington 1:9.25
6 Norma BR 1:8	.280 Remington 1:9.25
.25-’06 Remington 1:10	7x64 Brenneke 1:9
.257 Roberts 1:9.5, 1:10	.284 Winchester 1:9
7mm Winchester Short Magnum 1:9.5	.35 Whelen 1:14, 1:16
7mm Weatherby Magnum 1:9.25, 1:10	.358 Norma Magnum 1:12
.28 Nosler 1:9	.350 Remington Magnum 1:16

7mm Remington Ultra Magnum 1:9.25	.357 Magnum (rifle) 1:16
7mm STW 1:9.25, 1:10	9.3x62mm 1:10, 1:14
.30 Carbine 1:16	9.3x64mm 1:14
.30-30 WCF 1:12	9.3x74mmR 1:10, 1:14
.30 T/C 1:10	.375 Holland & Holland Magnum 1:12, 1:14
.30/40 Krag 1:10	.375 Ruger 1:12
.308 Winchester 1:10, 1:12	.375 Remington Ultra Magnum 1:12
.300 Savage 1:10	.375 Weatherby Magnum 1:12
.30-06 Springfield 1:10	.378 Weatherby Magnum 1:12, 1:14
.30 Nosler 1:10	.375 Dakota 1:12
.300 Winchester Magnum 1:10	.375 Winchester 1:12
.300 Winchester Short Magnum 1:10	.405 Winchester 1:14

.300 Remington Ultra Magnum 1:10	.450/400 3-Inch NE 1:15
.300 Weatherby Magnum 1:10	.404 Jeffery 1:14, 1:16.5
.30-378 Weatherby Magnum 1:10	.416 Rigby 1:14
.300 Holland & Holland Magnum 1:10	.416 Ruger 1:14
.308 Norma Magnum 1:10	.416 Weatherby Magnum 1:14
.300 Remington SAUM 1:10	.416 Remington Magnum 1:14, 1:16.5
.303 British 1:10	.416 Barrett 1:11
7.62x39mm 1:10	.500/416 NE 1:14
.32 Winchester Special 1:16	.44 Magnum (rifle) 1:20, 1:38
.325 Winchester Short Magnum 1:10	.444 Marlin 1:20
8x57mm Mauser 1:9.25	.45/70 Gov’t 1:20

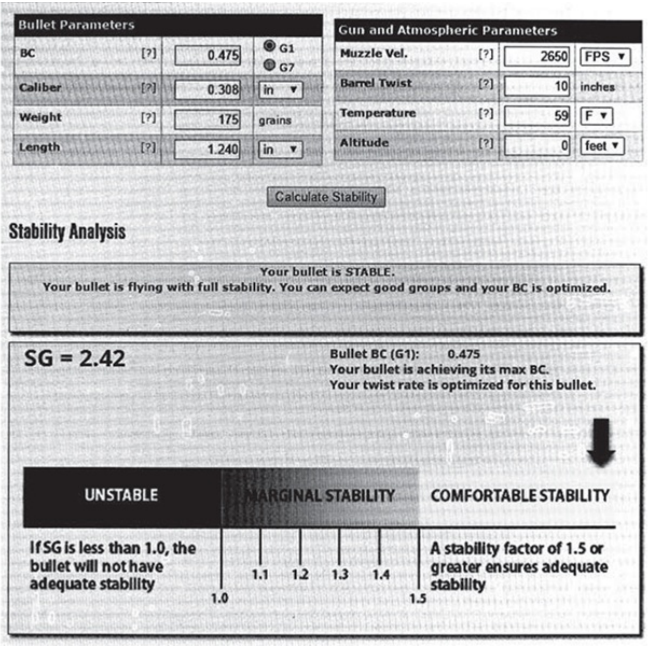
8mm Remington Magnum 1:10	.458 Winchester Magnum 1:14
8x68S 1:11	.458 Lott 1:14, 1:16
.338-06 A-Square 1:10	.450 3 ¼-Inch NE 1:16
.338 Federal 1:10	.450 Rigby 1:10
.338 Winchester Magnum 1:10	.458 SOCOM 1:14, 1:18
.338 Remington Ultra Magnum 1:10	.450 Marlin 1:20
.338/378 Weatherby Magnum 1:10	.460 Weatherby Magnum 1:16
.340 Weatherby Magnum 1:10	.470 NE 1:21
.33 Winchester 1:12	.500 NE 1:15
.338 Lapua 1:9	.500 Jeffery 1:17
.35 Remington 1:16	.505 Gibbs 1:10
.358 Winchester 1:14, 1:16	

So, it’s important to know what the twist rate of your barrel so you can choose the proper ammunition for your gun. There’s an easy way to observe, or verify the twist rate of your barrel. Using a cleaning rod, affix a tight patch and get it started down the bore. With a magic marker make a small mark at the base of the rod at the top, and another one where it meets the breech (or the muzzle in the case of a lever gun, slide, etc.). Push the rod down the bore until the mark makes one complete revolution, and make another mark at the same reference point

(breech or muzzle). Measure the distance between the marks to determine how many inches it took to make one revolution, and *voilà!* you’ve got the twist rate.

If you look at some of the long-range bullets, like the Nosler AccuBond Long Range, or some of the Berger offerings, they will indicate the required twist rate needed to stabilize their particular bullet. If you want a bit more information, or should the bullet be marginal for your twist rate, you can consult the Berger website (www.bergerbullets.com/twist-

rate-calculator/) and plug in all of your information. Based upon the Miller Twist Rule (more about that in the exterior ballistics section), the Berger calculator will provide you with the level of stability (or instability) of your particular barrel/cartridge/bullet combination. It’s a very useful tool, which can help you optimize your setup.



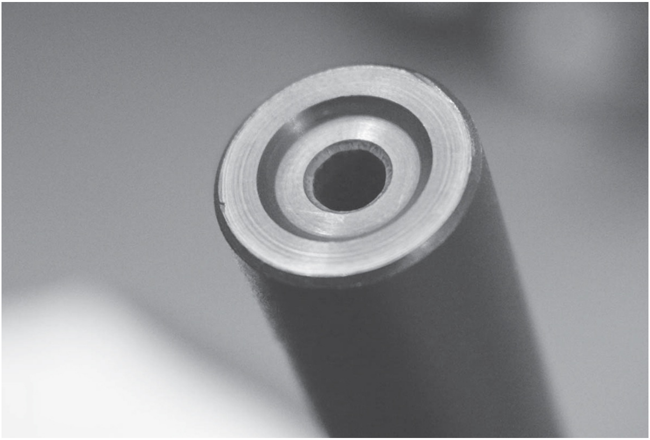
Bullet Parameters
BC [?] 0.475 G1 G7
Caliber [?] 0.308 in
Weight [?] 175 grains
Length [?] 1.240 in
Gun and Atmospheric Parameters
Muzzle Vel. [?] 2650 FPS
Barrel Twist [?] 10 inches
Temperature [?] 59 F
Altitude [?] 0 feet
Calculate Stability
Stability Analysis
Your bullet is STABLE.
Your bullet is flying with full stability. You can expect good groups and your BC is optimized.
SG = 2.42
Bullet BC (G1): 0.475
Your bullet is achieving its max BC.
Your twist rate is optimized for this bullet.
UNSTABLE
MARGINAL STABILITY
COMFORTABLE STABILITY
If SG is less than 1.0, the bullet will not have adequate stability
1.0
1.1
1.2
1.3
1.4
1.5
A stability factor of 1.5 or greater ensures adequate stability

THE CROWN

The final point of the barrel, where the bullet exits, is referred to as the crown. A uniform, even crown is invaluable for good accuracy, as it is the very last thing that your bullet will touch before embarking on its journey through the atmosphere. You’ll need to know about the varying types of crowns, and how they affect the flight of the bullet. Looking at the end of your barrel, you may see a simple, rounded end, and be able to feel the lands and grooves with the pad of your finger. Or you may see a square-cut, recessed affair, known as a

target crown. In any instance, you’ll definitely want to be careful with the crown of your firearm; it plays a very important role in its accuracy. I’ve seen my fair share of well-worn lever-action rifles, which need to be cleaned from the muzzle end, sporting worn or nearly eroded crowns from years of swabbing with a filthy aluminum rod. I’m sure if their owners, who were tough as nails and certainly knew how to shoot those guns, saw us today with our polymer bore guides and ball-bearing-handled, nylon-coated cleaning rods, they’d certainly

have a chuckle. However, if they could see the difference in accuracy between a healthy crown and a worn one, they’d have no choice but to admit that our methods preserve rifle accuracy better.



The target crown of the author’s Savage Model 116.

An imperfect crown can be the demise of accuracy. I went mildly insane trying to figure out what was wrong with that .22-250 Remington of mine, as I simply

couldn't figure out why it wouldn't shoot boat tail bullets. I mean, I tried factory ammunition, handloads, you name it. Because it is a flat-shooting cartridge, I wanted the 53- and 55-grain boat tail match bullets to work. My pal Donnie Thorne, better known as Col. Le Frogg, weighed in on the matter, and found the cure in one simple sentence: "Try some flat-base match bullets."

Long story short, once I switched to flat-base bullets, the rifle was printing ⅓ MOA groups out to 200 yards, which makes up a huge portion of my shots with

this rifle, unless the coyotes are posing across the hay lots. The crown of this Ruger rifle is less than perfect, and the escaping gas was being pushed on one side or the other of the exiting boat tail. Switching to a flat-base bullet improved the accuracy immensely, and was not a handicap as far as wind deflection and trajectory are concerned. To be honest, the combination of the imperfect crown and slow twist rate should warrant re-barreling the rifle, but I love the way it handles, so I'll wait a while until I feel it's time to do so.

Lever-action rifles must be cleaned from the muzzle, resulting in wear that can degrade the barrel crown and thus the rifle’s accuracy.

TWIST DIRECTION

Most of today’s barrels use a right-hand twist; that is, the bullet is spun in a clockwise motion. However, you can come across a left-hand twist barrel, spinning bullets in a counterclockwise motion, and when the distances get out beyond 500 yards or so, the spin direction of the barrel comes into play. A right-hand twist barrel will cause the bullet to

drift a measurable degree to the right when the time of flight increases. Conversely, the opposite is true for a left-hand twist barrel, and these considerations must be accounted for when trying to accurately place your bullets on a distant target. Many of the ballistic calculators incorporate twist direction as one of the parameters for long range dope, so it's important to know. One glance down your barrel and you can easily verify the direction of twist.

BARREL CONSTRUCTION

Steel has long been the chosen material for barrels. It is rigid enough to withstand the intense pressures generated by modern cartridges, yet flexible enough to allow the bullet down the barrel without cracking or shattering. The two most popular types of steel barrels produced are chrome-moly (a chrome-molybdenum alloy steel), and stainless steel. I’ve had excellent results with both, and I honestly feel that either will make a suitable choice for a barrel. Both give long life and are equally accurate, at least in my experiences. Stainless is a bit less

susceptible to rust (though not impervious), and chrome-moly can be a bit lighter, but I own and like both types. More important to me is the construction method used to create the barrel.

CUT VS. HAMMER-FORGED VS. BUTTON-RIFLED

Most factory barrels in production today are hammer-forged, cut, or button-rifled. All three methods have positive and negative attributes. Personally, I've found good and bad in all three types

along the way, and as long as a barrel does its job, I’m good with it. The cut barrels are probably the most labor intensive, as the rifling is cut one groove at a time in a reamed bore. Krieger, who made the barrel for my .318 Westley-Richards, makes cut barrels. The button-rifled barrels are made in a similar fashion, in the fact that a drilled bore at less than caliber size is utilized to guide the cutting button down the bore. Button rifling is popular with many custom rifle companies like Shilen, as well as Savage rifles — both of which have an

impeccable reputation for accuracy. So, with both cut and button rifling, a smaller-than-caliber hole is drilled through the centerline of the bore, and a tool is used to put the finishing touches on the barrel.

The ‘standard’ crown of a Winchester Model 70.

The stainless steel barrel of the Savage Lightweight Hunter.

Hammer-forged barrels work in the opposite manner. They start with a barrel blank that gets reamed to a dimension larger than the desired caliber, and then a

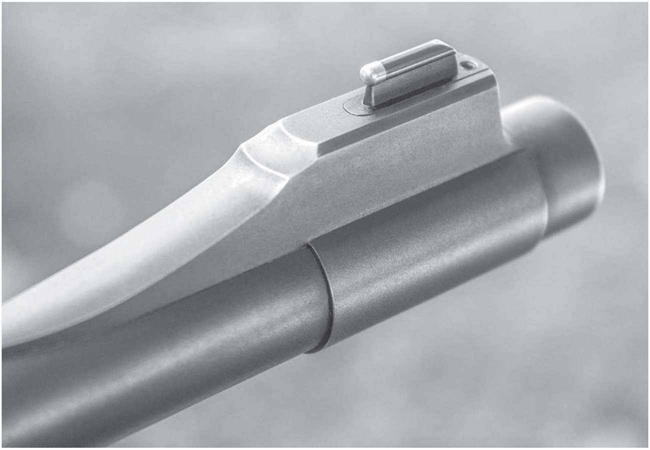
mandrel that is a perfect mirror of the desired bore dimension is inserted into the reamed hole. At that stage, a series of hammers are used to forcefully mold the steel around the mandrel, so that the resulting bore comes out perfect. Undoubtedly, hammer-forged barrels are both cost-effective and accurate, yet some folks feel that they are the least accurate type of barrel. I’ve had some of the best — and worst — accuracy with a hammer-forged barrel, yet I feel it’s due to the fact that they represent such a large portion of the barrels produced each year.

My Heym Express .404 Jeffery uses a hammer-forged Krupp barrel, and yet it gives sub-MOA accuracy consistently. Likewise, I’ve got a trio of Winchester Model 70s (.300 Win. Mag., .375 H&H and a .416 Remington Magnum) and all have exhibited excellent accuracy, accompanying me on hunts all over the world. Likewise, my favorite revolver, a Ruger Blackhawk in .45 Colt, uses a 7.5-inch hammer-forged barrel that allows me to hit targets as far as I can hold accurately. The hammer-forged method occasionally gets a bad rap because it is

associated with mass production, but that’s not fair. Heym rifles, makers of some of the finest safari guns available, make approximately 6,000 hammer-forged barrels annually, but only consume about 2,000 for their own in-house use. The remainder are sold to other fine rifle companies, and I’ve yet to meet a Krupp barrel from Heym that didn’t perform very well.

The button-rifled barrel of the author's Savage Model 116 in 6.5-284 Norma.

An employee at the Savage plant in the process of button-rifling a barrel.



The hammer-forged barrel of the Heym Express in .404 Jeffery.

DOWN THE RABBIT HOLE

When the cartridge is fired, the primer sends a shower of sparks into the powder

charge, which is burned. The resulting expanding gas creates lots of pressure. This sends the bullet in the path of least resistance: down the barrel. It’s also when things get interesting, as the entire situation changes in an instant. Once the bullet passes the throat and engages the rifling, the torque creates a wave of distortion that causes the barrel to swell just in front of the bullet. The barrel will — although minutely — swell and return to original shape as the bullet passes down the bore. In addition, the barrel will ‘whip,’ as if you were holding a fishing

pole in your hand and quickly shook your wrist. Barrel flexure is minimized with a larger diameter barrel of shorter length, but those shapes come at the cost of velocity loss and increased weight. In addition, if your barrel is not ‘free floating,’ meaning that it is touching the stock at some point, accuracy can be affected. Like all things in life, there are no absolutes, and I’ve seen rifles with Mannlicher stocks where the stock extended to the muzzle and touched almost all the way exhibit excellent accuracy. Many military rifles such as the

M1 Garand or M98 Mauser have stocks that extend much farther than do our common hunting and target rifles. Yet, these have shown some amazing capabilities in competition shooting … in no small part to the men behind the trigger. That aside, I prefer my rifles to have barrels free floated so they can swell and torque and whip without interference. That keeps things as accurate as possible. You can test your rifle’s barrel channel by placing a dollar bill under the barrel, and run it up along the stock toward the receiver as a feeler gauge to see if the

stock is touching the barrel at any point. If it is, remove a small amount of material from the barrel channel in order to let the barrel move freely during the shot.

The carbon fiber barrel of a Hillbilly Rifles .300 WSM.

The hammer-forged barrel of the Ruger Blackhawk .45 Colt.

The idea of reducing barrel whip by using a stiffer (larger diameter) barrel isn’t a new one, but it definitely works. It

not only dissipates heat better, but reduces the amount of flexure to give a more repeatable result, promoting accuracy. The bull barrel is a staple of the target community, as well as being a popular choice among varmint hunters who must hit distant, tiny targets. However, they are heavy to carry, and can be very unwieldy to shoot offhand. Now, I don’t mind a barrel on the heavier side of things, particularly the semi-bull barrels that make a good blend of portability and stability, but I don’t want a bull barrel on the mountain hunts of the

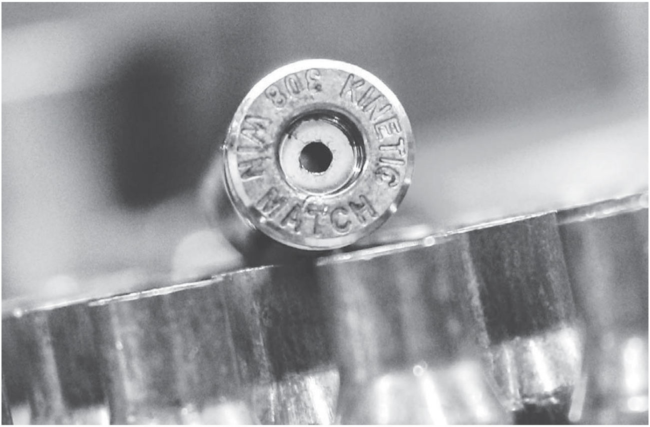
Adirondacks and Catskills, nor do I want one when in the African game fields, where the daily walks are measured in miles. There is a way to get the best of both worlds, using a light, rigid, carbon fiber. Starting out with a featherweight steel barrel, carbon fiber is wrapped around it, until it achieves the diameter of a bull barrel approaching one inch or more in diameter. This combination is lightweight like a slim steel barrel, but has the rigidity of a bull barrel. The carbon also dissipates heat very well, keeps your barrel cooler, longer.

When a barrel gets too hot, it’ll tend to print a bit higher on the target. This occurs because the steel expands, and the bore diameter is slightly reduced, creating a higher pressure and thereby more velocity. Heating your barrel to the point that it is impossible to touch without pulling your hand away is never a good idea, as it will lead to premature barrel wear and throat erosion. Allow things to cool, and a barrel should give nearly a lifetime worth of service.

HARMONICS

The manner in which a barrel whips, torques and contorts is referred to as ‘barrel harmonics.’ The idea of accuracy is simply a set of repeatable barrel harmonics. If you use the centerline of the bore as the baseline for your observations, you would see a wave in which the barrel would rise and fall, equally above and beyond the baseline. The thinner and longer a barrel is, the further from the baseline the barrel will whip. Again, a short, thick barrel will have a much smaller deviation from the baseline. Accuracy is optimized when

harmonics are repeatable, and when the various pressure waves align in such a fashion that the muzzle diameter is kept at a uniform dimension. Um, what? How can the muzzle diameter change? Allow me to explain a complicated theory in simple terms.



Kinetic .308 Winchester match brass was used in the seating depth experiment.

I ran across a theory, presented by radio communications engineer Chris Long, which makes a whole lot of sense and explains some ideas I knew to be

true, but had no idea how to nail down scientifically. It also changed the way I look at my own handloaded ammunition. Long purports that a series of crossing waves can, will, and do have a great effect on the barrel and its ability to produce a repeatable point of impact (known to us as a tight group). While I am not a scientist (cue Star Trek music: "Dammit Jim, I'm a surveyor not an engineer!") Long's theory boils down to this: the ignition of the powder charge creates pressure that sends a shockwave down the barrel, to the muzzle and back

again, in a repeating fashion much like the plucking of a guitar string. This ignition stress shockwave can and will move the steel enough to cause a distortion in the bore diameter. Subsequently, when the bullet engages the rifling, a second force — the swelling of the barrel ahead of the bullet — starts to travel toward the muzzle. According to Long’s sound theory, if those two waves collide when the first wave is affecting the muzzle, the groups will open up as if the crown were out of round, much like my .22-250 Remington was behaving. If

you can find the load with which the two waves are separated, the group size will indeed shrink.

Now, there are many variables in Long's equation, including the amount of powder and the load density, as well as the seating depth of the bullet, and while this isn't a book on reloading ammunition, this theory makes perfect sense to me as a handloader. It can easily explain how changing the powder charge a mere 0.1 or 0.2 grains would so dramatically affect group size, as I've seen for decades in my own handloaded

ammo. In addition, the Chris Long theory also explains why some barrels like a particular brand of ammunition, yet others can’t get it to work at all. I think it also explains the drastic changes in group size that can occur when changing seating depth and cartridge overall length. (Which incidentally has been a little trick of mine for years, though I didn’t understand exactly why it worked, I just knew that it did.) The variations in seating depth will definitely affect the barrel harmonics and their timing.

A SEATING DEPTH EXPERIMENT

With this information in hand let’s run a little experiment using a proven rifle that is capable of ½MOA accuracy, to see how important of a role seating depth plays in the barrel/accuracy equation. Marty Groppi and I took a proven load, and varied the seating depth of the bullet in increments of 0.005 inches to see whether or not it made a significant difference. We knew what this gun would do at 100 yards, so to magnify the differences in group size we took things

out to 300 yards for the test. My pal Mark Nazi was kind enough to lend his Remington 700 in .308 Winchester, and we headed to the reloading bench to cook up the ammo we'd need. This rifle shines with a particular load of Hodgdon's Varget powder, and a Federal GM210M large rifle primer. To keep things as uniform as possible, we used Kinetic Industries' match .308 brass, full-length resized in a good set of Redding Competition dies. For a bullet, we used the Sierra 168-grain Tipped MatchKing; again, I wanted an accurate, uniform

projectile for test purposes, and it’s really hard to beat the Sierra TMK. So, being limited by the design of the bullet ogive, we started at the SAAMI overall length of 2.800 inches, and then set the bullets out longer in 0.005-inch increments until we reached 2.835 inches — first verifying that the longest load was not touching the lands and grooves. Mark’s rifle has a particularly long throat, and our longest cartridge was still in the clear. Below is a chart, but I’ll describe the chain of events that led to the results.

The 168-grain Sierra Tipped MatchKing.

I put my buddy Manny Vermilyea on the trigger and we first affirmed zero at 100 yards, and checked the five-shot group size. As expected, it was just over

½MOA, so we then started with the shortest load (that is, the SAAMI dimension load) at 300 yards. The first group printed just shy of 3 inches, or 1 MOA at that distance, with an average velocity of 2,638 fps, proving two things: that even though outside air temps pushed 90°F the load was performing as we expected, and Manny was shooting properly.

As the seating depth increased in increments up to 2.815 inches, we saw an increase in velocity (to be expected as you seat bullets out further) and we saw a

definite degradation in accuracy. The 2.805 and 2.810-inch groups opened up to 5.25 and 4 inches, respectively, and maintained the slight increase in velocity. At 2.815 inches, the five-shot group came back down to 3 inches, with another velocity bump up to 2,660 fps. However, at 2.825 inches we found a sweet spot; the velocity dropped down to an average of 2,644 fps, with the lowest standard deviation on velocity, and a group size of exactly 2 inches. We had found the proper barrel harmonics for this rifle/bullet combination. Further retesting

showed similar results in both group size and uniform velocities. At an overall length of 2.830 inches our velocities bumped back up to 2,652 fps and the group size opened up to just over 4 inches. It got worse with the 2.835-inch load, where we saw the first signs of high pressure in some slightly flattened primers.

.308 Winchester	Kinetic Match Brass	Redding Competition Dies
Federal GM210M primer	43.5 gr. Hodgdon VARGET	Oehler 35P chronograph

Cartridge Length (inches)	Avg. Velocity (fps)	Five-shot group size @ 300 yds. (inches)
2.800	2,638	3.0
2.805	2,644	5.25
2.810	2,650	4.0
2.815	2,656	3.0
2.820	2,660	2.5
2.825	2.644	2.0
2.830	2,652	4.0
2.835	2,657	4.75

Our cartridges only changed a grand total of 0.035 inches in length, yet the same powder charge and components showed a radical shift in accuracy.

Thinking about Chris Long's hypothesis, his barrel harmonic theory made perfect sense. The minute changes in seating depth cut the group size in less than half at 300 yards, without any changes to the powder charge. Barrels, they are finicky creatures indeed.

During load development for my 6.5-284 Norma, I found the same effect of seating depth on the rifle's accuracy. From the time I opened the box, this rifle would put many different types of ammunition into less than 1 MOA without issue. As my load development

got more experimental, I tried radically changing the seating depth. This particular rifle was ordered from the Savage Custom Shop on the Model 116 action, much longer than you'd traditionally need for the 6.5-284 Norma, but I wanted the ability to seat the bullets out as long as the throat would allow. That gun likes H4831SC powder, and it likes it a lot. However, when using the Hornady ELD-Match 140-grain bullets and the same load of H4831SC, I tried seating them out so far that the bullet's shank was just at the bottom of the case

neck — giving good neck tension, but using a much longer overall length than normal. The accuracy fell apart. When I returned to the shorter seating depth that I'd stumbled onto during earlier experimentation, things tightened right back up.

BARREL LENGTH AND ITS EFFECTS

For years, it was a common assumption that longer barrels were more accurate than shorter ones. It's an arguable point, but I've seen evidence that points to the fact that both can be

equally accurate. I do believe that when discussing iron-sighted guns, a longer sighting radius will usually result in an ability to place the shot better, but in a scientific world — say using a machine rest — I’m not certain that the longer barrel will always come out on top.

Performing a quality check on a gun barrel.

There is a definite increase in velocity when using a longer barrel, as the longer

pipe will build more pressure. The generally accepted velocity loss/gain when comparing barrel lengths is 25 fps per one inch of barrel length. While I’ve never had the opportunity to actually measure the velocity loss of one particular barrel by cutting off an inch at a time, I’ve seen studies where this test was performed and that rule was more or less proven. For example, my 6.5-284 Norma is a popular choice among F-Class shooters, and many of those rifles take advantage of the case capacity by using a barrel length of 28 or even 30

inches. My own Savage Model 116 with a 25-inch barrel doesn’t quite match some of the advertised velocities because of the shorter tube, and I’m OK with that. It’s a hunting rifle, and while I normally don’t mind longer barrels, toting a 28-inch barrel through the woods and fields seems a bit excessive to me. So, when I ordered the rifle, I figured the 25-inch length would make a good balance of velocity and portability. The choice is ultimately up to you, whether you want a compact rifle for ease of carry, or the long barrel for additional velocity, but it’s

important to know that the measured velocity of Brand X ammunition in your gun may not equal advertised velocities due to the difference in the test gun’s barrel length and the length of your barrel.

When I first started to handload ammunition, I didn't understand why a

particular load prescribed by the reloading manual didn’t obtain the velocity shown in the data. I followed the recipe exactly. Used the test data’s primer, powder charge, case, and bullet and seating depth. But I was still 125 fps below the manual. Then I glanced at the test rifle information. This company had used a universal receiver and a 26-inch barrel to arrive at their data, and my rifle sported a 22-inch barrel. Barrel length was the factor.

Pistol barrels can and will have a similar effect on the performance of ammunition. Many of the micro-carry, or pocket pistols, give lower velocities than

their full-sized counterparts due to the decreased barrel length. Ammunition companies have made an effort to optimize the cartridges for best performance in the shorter barrels. Federal Premium HST ammo has a ‘Micro” line that is designed to function properly in the shorter barrels of concealed carry pistols, and it works very well. My own carry gun — a Smith & Wesson Model 36 in .38 Special — has the 1 ⅞-inch snubnose barrel and, while the velocities certainly aren’t what you’d get from a 4- or 6-inch target gun, I knew

that when I purchased it. For distances at which I feel comfortable using a short-barreled pistol, I’m fine with the velocity loss in exchange for ease of carry and concealment.

These are things to keep in mind when purchasing a rifle or pistol. Does a .308 Winchester need a 26-inch barrel? Probably not, because the case capacity can be utilized in a 20- or 22-inch barrel, and if it’s made properly, should offer fine accuracy. Can you get the most from a 7mm Remington Magnum with a 22-inch pipe? Not likely. This is an example

of a cartridge needing a bit more barrel length to achieve optimum results, due to the increased case capacity. Will a short-barreled handgun be as accurate as a longer barreled one? Maybe, but it has more to do with balance and the ability to aim the firearm than actual function of the barrel and its length. Will a 20-inch barreled Winchester 94 carbine, in .30-30 WCF, perform as well as the 26-inch octagon barreled rifle of your grandfather's era? For the distances at which a .30-30 is most commonly shot, I'd vote yes, but again, that longer

sighting radius of the bigger rifle may cause it to appear more accurate than the carbine, so it would take a machine rest to verify the results. For a hunting application, either is more than acceptable if you practice diligently with an iron-sighted gun (which seems to be a lost art these days), so if you appreciate the compact design of the carbine, have at it.

SECTION II
EXTERIOR BALLISTICS

SECTION II: **GUNDEX®**

CHAPTER 12

CHAPTER 6
EXTERIOR BALLISTICS EXPLAINED

The primer has been struck, the powder burned, and the bullet acted upon in a most violent chain of events. Yes, our proud little metallic fledgling has left the nest! Into free air it is sent, rotating rapidly, on its course to an unknown destination. Immediately, a multitude of

alien forces begin to act upon it as it rolls with the punches and reacts accordingly.

Obviously, not all bullets are built in the same fashion, and each of them react differently to the forces of their particular environment. Some are sleek and streamlined, like a fighter jet, designed for the utmost speed and efficiency, while others are built like a tank, square and strong, to breach the strongest defenses. As with mechanized implements on the battlefield, the two extremes in bullet design use completely different means to

the same end, and have different applications.

Exterior ballistics deals with that portion of the bullet's flight from the moment it leaves the muzzle until it impacts its target — whether that target is paper, steel or flesh. In a handgun, especially a defensive arm, the flight of the bullet is rather short, and the atmosphere and laws of physics have less opportunity to influence things. In a high-powered rifle, these forces have plenty of time to show their effects. To be able to put that bullet precisely on target, you

need to fully understand how the bullet will react to your environment at a wide variety of ranges. Entire lifetimes have been spent in pursuit of the accurate prediction of bullet trajectories. While the answers are out there, the science of ballistics is constantly evolving, and our ability to quantify and predict the values associated with the bullet’s path is improving all the time.

There are scientific terms associated with exterior ballistics, and they can be confusing at times. The most prevalent term we’ll need to understand is ballistic

coefficient, or BC as we’ll see it abbreviated, a term that describes the bullet’s ability to resist the effects of atmospheric drag and wind drift, as compared to the base models of bullet shapes as defined by the *Commission d’Experience de Gavre*. That was where a series of tests were performed at the Aberdeen Proving Ground, Maryland, by the U.S. Army in the early 1880s, and the G1 bullet form (G in honor of Gavre) was adopted as the model for comparative purposes. Almost all of today’s bullets are labeled with a BC based on the G1

model, although there are newer and different models that better serve the shooter (we'll get into detail about that later in this section).

The accuracy of a particular firearm is most often measured in the arc subtended by a minute of angle, abbreviated as MOA. One minute of angle is 1/60th of one degree on a circle, and is equal to 1.047 inches at 100 yards. For our general purposes, assume that figure as one inch. Thus one MOA is one inch at 100 yards, two inches at 200 yards, three inches at 300 yards, and so forth. A rifle

that is said to shoot MOA will print a group of shots that measure no more than one inch of extreme spread at 100 yards. Since group size is measured in a function of a projecting cone, the further the distance the target is from the muzzle, the wider the arc subtended by that angle. For hunters facing shots inside of 400 yards, an MOA rifle should print a group measuring four inches at the 400-yard mark.

Wind drift is the effect of any crosswind during the bullet’s flight. It is a tricky proposition learning to ‘dope’ the

wind, but it is necessary to hit distant targets in real world situations. Wind will certainly blow a bullet off its course in a horizontal direction, but in certain situations it will have a vertical effect as well. Wind drift is typically represented in inches, but I’ve seen it in MOA as well. I personally prefer inches, but the two are easily converted. MOA is an important value for precisely adjusting telescopic sights.

Now, the trajectory of a bullet is based on more than one factor. Shortly after Sir Isaac Newton had his noodle rocked by

that fateful piece of fruit (I’m thinking back to the wonderful Schoolhouse Rock cartoons of my youth), he did his best to explain the laws of gravity. The resultant accepted formulae state that, with the effects of atmospheric drag aside, all small bodies will fall to the earth at the same rate. This applies to projectiles as well. Whether fired at Mach III or simply dropped from your hand, the bullet falls to the ground in the same amount of time. When a rifle is described as flat shooting, it is because it generates a higher than normal muzzle velocity, and the bullet is

allowed to cover more ground before gravity pulls it earthward. The flattest shooting cartridges have the shortest time of flight (abbreviated TOF), so that the represented curve of the bullet path looks much flatter than the slower cartridges. Combine this gravitational effect with the effects of air drag, crosswind, and atmospheric conditions, and your projectile has much to overcome before it tears out the bullseye. You can now see why the science of ballistics is so in-depth.

There is a common misconception about trajectory that can be easily misconstrued from looking at the trajectory curves printed on the back of ammunition boxes. I’ve had many people argue until they were red in the face that a bullet rises once it leaves the muzzle, and starts to drop in a rainbow-like curve. That, dear reader, is simply not the truth, though it is necessary to adjust the way you use your firearms to have that be the end result. If you were to hold any firearm so that the line of the bore were perfectly level (perpendicular to

gravitational pull), your bullet would immediately start to drop below the line of the bore, essentially never striking a target exactly where the bore was aiming, irrespective of distance to the target. There would be some (perhaps minuscule) gravitational pull. Coupled with that idea, the manner in which you sight your firearms — whether with iron sights or telescopic sights — requires your visual plane be elevated at some distance above the bore line. So, with those two factors involved, you must elevate the bore at a certain angle upward

so that the bullet path and the visual plane will cross at two specific distances. The flight of the bullet must begin below the visual plane, then rise above it, and finally cross the visual plane once again after gravity and air drag have had their time to act. The distance at which the bullet crosses the visual plane for the second time is commonly referred to as ‘zero.’ A rifle zeroed for two-hundred yards means that the curve of the bullet path will leave the muzzle, cross the visual plane at 25 to 50 yards (strongly dependent on the type and velocity of

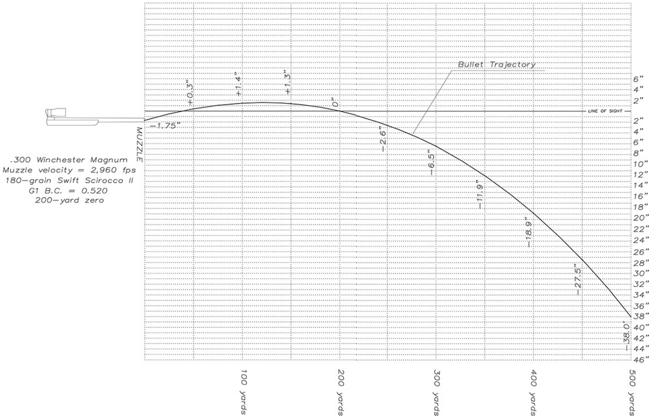
cartridge you’re using), rise a small distance above the line of the visual plane, and meet the line of the visual plane at exactly 200 yards from the muzzle.

The farther the bullet gets from the muzzle, the more drastic the effects of the atmosphere and gravity become. That ballistic coefficient or BC figure — again, the comparison of the ability of your bullet to overcome air drag and wind drift with a particular model — is not a static figure; it changes over a range of velocities. Often when the bullet

manufacturer lists a BC figure for their bullet, it is in comparison with the G1 bullet model (a model that simply doesn’t best describe most of today’s bullets) as well as being an average of the changing BC over a variety of distances and velocities. While it serves as an approximation, there are better means of representing the highly specialized bullets of the modern era, the ones that truly require an accurate representation as they are used for long-distance work.

As a reminder, the sectional density, or SD, is a ratio of the bullet’s mass

(weight) to its bore diameter. While we'll be using this characteristic much more in the terminal ballistics section, for the purposes of external ballistics your bullet's SD figure is an important part of deriving its form factor, in comparison to a G1 or G7 bullet model, and that in turn is used for the derivation of an accurate BC.



There are also the rotational effects of a bullet that need to be taken into account for true long-range accuracy. That same spin that the barrel's rifling imparted on the bullet not only keeps it stable in flight, but causes an effect known as spin drift at extreme ranges. If you're serious

about long-range shooting, you’ll want to know how to calculate and adjust for it.

CHAPTER 7
FACTORS AFFECTING THE BULLET IN FLIGHT

Once that projectile leaves the muzzle of the barrel spinning at a prescribed rate, having received all the propulsion it possibly could have from the specific powder charge that was designed for it, there are a number of forces that begin to

act. Gravity, friction (caused by the atmosphere into which it was delivered), and wind drift being chief among the culprits, the poor bullet isn’t quite sure what to do. Hopefully, the bright-eyed humans who designed the launching tube — that piece of steel we call a barrel — have understood the physics of their environment well enough that the projectile is spinning at a rate sufficient to provide a smooth, stable flight, with as little interference as possible during its journey.

GRAVITY

Gravity, that annoying force that draws all things toward the center of our planet,

has a definite effect on bullet flight. All objects fall toward the earth’s center at the same rate. If you were to drop a stone from your hand, it will fall at the same rate as if you threw it as hard as you could on a line perpendicular to the line of gravity.

The same principal can be applied to projectiles. As explained earlier, when we say that a particular cartridge is ‘flat-shooting,’ it is due to the fact that a higher than normal muzzle velocity allows for the bullet to cover more ground before it begins to fall due to

gravity. The more aerodynamic the bullet, the less it will be affected by the friction of the atmosphere. Concurrently, an aerodynamic projectile will be less affected by crosswind drift. As I stated earlier, the quantification for the aerodynamic properties of a certain shaped bullet is called its ballistic coefficient. This figure is rather difficult to describe, and harder to understand, as it is a comparison to a particular model, not a static number. The figure is represented as a definite number by many of the bullet companies (Sierra Bullets

gives a varying BC figure for different velocity ranges) but is actually a variable, affected greatly by velocity, and changing throughout the velocity spectrum. In other words, though it may only be a slight change, a bullet's BC will indeed change throughout the entire course of its flight. For true long-range work, you should be able to compute these figures to best hit a distant target, and some of the ballistic calculating programs can be a great aid in these calculations.

Again, let's not lose sight of the big picture. What kind of shooter are you? If

you’ve purchased this book, you have an interest in long-range ballistics, or at least ballistics in general. If you’re like me and limit yourself to what I call ‘sane’ hunting ranges, say 350 to 450 yards, the more minute points of ballistic coefficient may be lost on you. Yes, at ranges beyond 200 or 250 yards the boat tail bullet begins to show its benefits with respect to both trajectory and wind drift; but I can tell you with certainty that I’ve made shots out past 350 yards with what most would consider the most unfavorable bullet profile. Not to say that

it’s all bunk, and those of us who stay within 450 yards need not understand the minutiae, but realize that once you get out past 500 yards the small details make a much bigger difference. There are many different hunting and/or shooting situations in the world, and each has a different application.

It’s a long way to that steel plate, with plenty of opportunity for the wind to wreak havoc.

Me? I limit myself to ranges inside 450 yards, and then only under perfect

conditions. As a target shooter, I absolutely love the long-range game, but local conditions limit the distances to 500 yards. So, as a result of many different conditions here in my home state of New York, in addition to the multitude of situations that I’m faced with as a global hunter, I have to adapt the ammunition and bullet choices to the job at hand.

WIND, THE UNSEEN ENEMY

Wind drift is a more difficult parameter with which to deal than is gravity. The effect of crossing winds on a bullet’s

flight path is dramatic, and often less easy to predict than the effects of gravity. The weight and speed of your projectile come into play here, as well as its shape. I grew up hunting in Upstate New York, where the effects of the wind are negligible at best, unless you were a dedicated woodchuck hunter who prowled the hay lots and orchards; even then the truly windy days didn’t give a lot of action. I was on safari in the Orange Free State of South Africa in 2004, hunting eland with my prized Winchester Model 70 in .375 H&H Magnum. We had

tracked a herd for nearly a mile when we caught sight of them, but there was a problem. They were feeding slowly across a wide open plain, but were 400 yards out with no cover available whatsoever to make an approach possible. We laid down next to a small termite mound and had a brief, curt discussion. My Professional Hunter firmly believed I could make the shot, and encouraged me to use my pack for a rest to be as steady as possible. Now, I know that rifle very well and had carefully handloaded all the ammunition

and knew the gun was MOA out to 250 yards, even prepared a drop chart out to 400, but we had a 20 to 25 mph crosswind, right to left. I knew the vertical holdover to compensate for bullet drop, but that wind! With a muzzle velocity of 2,500 fps on the button, I knew it didn’t have the ‘frozen rope’ trajectory of some of the lighter caliber magnums, but the 300-grain bullet wouldn’t be horrible in the wind. The Swift A-Frame is a semi-spitzer design, with a decent ballistic coefficient as compared to the round-nosed bullets, but

it isn’t exactly optimum for true long-range work. However, this was the shot that presented itself, and we discussed these factors as we waited for the big bull to come clear of the cows. I did my best to recall all the data I’d looked at for this bullet combination, and figured 12 – 14 inches of lead would have worked just fine. As I started the squeeze, a small cow stepped into view and I backed off from the shot. I’m glad I did, as it gave me an opportunity to reevaluate the situation. I looked at the stunted grass near the eland herd, and saw the wind

was blowing much harder at the eland than it was where we were lying in wait.

When the bull cleared again, I adjusted the windage to give a full 20 inches of lead into the wind, and caressed the trigger. The sound that floated back on that wind was glorious; a bone-smashing *crack* — and once the rifle had recoiled I saw he'd taken that A-Frame right on the shoulder. We walked to within 200 yards and finished him. However, had that cow not interrupted the first shot, I'd have invariably hit him too far back, and might have lost him.

The second story I'd like to relate to demonstrate the point is a prairie dog shoot in South Dakota, where I had an opportunity to use many different rifles during the course of a week. My friend JJ Reich of Vista Outdoors had invited me and several other writers on a hunt, to unveil several new types of ammunition and rifles out on the Rosebud Reservation. The Dakotas have some of the biggest prairie dog towns I've ever seen, and as trees come at a premium on the open prairie, the wind was certainly going to be a factor. We were using

small-bore rifles: .17 HMR, .17 WSM, .17 Hornet, .22 Hornet, .22 Long Rifle, .22 WRM, .223 Remington and .22-250 Remington. In three full days of shooting, we had about two hours of truly calm conditions, so this was a great opportunity to observe and educate ourselves about the effect of wind drift. Rifles were zeroed at varying ranges, depending on their trajectory, and our guide Cliff would be helping us call the shots on the little rodents. We had shooting benches available, and I was paired with my friend Eric Conn, Editor

in Chief of *Gun Digest the Magazine*. Conn and I set up on the top of the small hill overlooking a dog town that stretched out to 600 or 700 yards. This experience opened my eyes to the wind's effects like no other shooting I've ever done. We had all sorts of Federal Premium and American Eagle ammunition, in varying configurations.

The author's practical knowledge of ballistics allowed him to adapt to the wind when hunting eland in Africa with this Winchester Model 70 .375 H&H.

A trophy eland bull, taken in the Orange Free State of South Africa.

The wide open, windy prairie of the Rosebud Reservation.

Velocity was key on this hunt, to minimize the time of the bullet’s flight, and therefore minimize the effect of wind drift. The .17 HMR is considered a decent long-range rimfire cartridge, pushing a 17-grain polymer-tipped bullet

at a muzzle velocity of 2,650 fps, while the .17 Winchester Super Magnum launches a 20-grain pill of similar profile and construction to a muzzle velocity of 3,000 fps. While using both cartridges, the .17 WSM showed a distinct superiority in the wind. And despite only a 350 fps difference between the cartridges, the WSM’s wind lead was measured in inches, while the HMR’s was measured in feet when both were shot in a stiff crosswind. While each bullet had enough striking power to quickly dispatch any dog with a solid hit,

the hits were easier with the faster cartridge.

The same conclusion can be drawn when comparing the .17 Hornet with the venerable .22 Hornet. While the .22 Hornet has been with us since my grandfather’s generation, and is a well-respected varmint cartridge, the younger sibling made the old guy look anemic. If I had to pick a second favorite cartridge on this particular trip — second by a nose to my old friend the .22-250 Remington — it would be the .17 Hornet. The 20-grain bullet driven to a muzzle velocity of

3,650 fps proved itself an absolute champion while working in the Dakota breeze, giving wind-bucking performance on par with the .223 and .22-250 within 300 yards. The .22 Hornet was solid within 150 yards or so, but the heavier, semi-spitzer design we were using began to drift severely outside that distance.

Playing the long-range game at the FTW Ranch in Barksdale, Texas.

The .223 Remington also enlightened me on this trip, as we had two different loads to compare in the field. The 50-grain hollowpoint load from the American Eagle Varmint and Predator line was on hand, as well as the Federal

Premium 62-grain Trophy Bonded Tip load. The American Eagle load runs at a muzzle velocity of 3,325 fps, while the Federal 62-grain bullet exits the barrel at 3,050 fps, and one would think that the higher velocity bullet would hold the advantage in the heavy crosswind. That wasn’t what I found to be true. The 62-grain slug needed several less inches of wind dope when shot in the same conditions in order to kill the dogs, despite being almost 300 fps slower than the 50-grainers.

After burning up over 1,000 rounds of ammunition, at distances varying from 45 to 450 yards and wind conditions changing from near calm to gale force, I knew after three days of nonstop shooting that I needed to know more about these parameters and how they affect the bullet flight path of my favorite rifles and cartridges. It was quite an education seeing the dust puff up from my misses, as well as having a guide with good optics and an incredible set of eyes to call my hits. It piqued my curiosity to learn more about these effects so I could better

predict the outcome of my shots.

OTHER CULPRITS

About a month later, I had pulled up to the front door of Tim Fallon's FTW Ranch, near Barksdale, Texas, as a student of the SAAM (Sportsman's All-Weather All-Terrain Marksmanship) Shooting course. The FTW is comprised of 12,000 acres of draws and canyons, with numerous shooting ranges that would combine distance, crosswind, elevation differences and both moving and stationary targets. The instructors are Navy Seals, well-versed and experienced

in all types of precision shooting, as well as being very familiar with the heavy bore safari rifles that would comprise a part of the training. These boys are shooters, and are great teachers as well.

I spent equal time with a medium-caliber 6.5 Creedmoor and my old safari friend: a Heym Express bolt-action rifle in .404 Jeffery. The first thing I found was a dope card for the rifles, giving all sorts of information about the downrange trajectory and wind-bucking capabilities of the two rifles, in addition to the necessary information about the

riflescope reticles I would be using, and how to reference certain points to make a long-range shot much easier.

In the classroom, instructor Doug “Dog” Pritchard delved into the data used to prepare these cards. A computer program asked for a variety of parameters to best calculate a trajectory and give a baseline for wind drift, taking into account air density, elevation, and spin drift caused by the rifling. Notable was the difference in trajectory while shooting in air of varying densities. It made logical sense that as elevation above sea level

increases, the air becomes thinner, and a projectile would meet less resistance in this type of air. Correspondingly, thicker air — nearer to sea level — would create more friction, and change the trajectory as well. Humidity and barometric pressure have an effect on a bullet’s path as well. Humid air is actually thinner than dry air, and will increase the BC of your bullet, something that will change the point of impact of a particular load when distance increases. If you routinely shoot at ranges over 500 yards, or are practicing for a sheep hunt or other

circumstance where a long shot may be required, it is important to know how the conditions of the atmosphere will affect your shot.

Knowledge is power, and there are tools available to provide it, like the Kestrel Elite Weather Meter, which allows you to measure and combat atmospheric effects to place the bullet where it needs to be. You need to know how to use these tools, and how to derive the changes in trajectory. Depending upon the particular weather conditions at your location, the atmosphere will affect

your bullet’s flight path. I can adjust elevation higher or lower than the baseline information.

The Kestrel Elite ballistic computer and weather station.

There is also the *Coriolis Effect*, which comes into play when distances get truly long. Summed up for our purposes, Coriolis is the effect of the rotation of the earth on a bullet in flight. The earth rotates (at the equator) at about 1,040 miles per hour. Converted to feet per second (fps) that’s a velocity of 1,525 fps. This speed is significantly less as you move toward either of the poles, because less ground is covered per revolution. This difference in ground speed, if you will, pushes a bullet’s point of impact to the right in the northern hemisphere, left

in the southern hemisphere. The horizontal correction for Coriolis is negligible until you get out to 1,000 yards and over.

Additionally, Coriolis will change the vertical point of impact if you are shooting along the east-west directional lines. Long-range shots to the east will hit higher than those fired to the west, because of the direction of the earth’s rotation. What is actually happening is this: a target east of your muzzle is actually sinking away from the bullet’s path as the earth rotates, so the impact on

the target will hit higher than if it were fired in a north-south direction (where this effect is negated), while shots fired westward hit low, because the earth's spin is causing the target to rise.

You see, the longer the time of flight of a bullet, the more time the earth has to spin. This vertical effect is maximized at the equator, minimized at the poles. For both horizontal and vertical correction, your latitude must be known to make the proper correction. While this correction is too small to be significant for most hunting situations, the long-range target

crowd will appreciate the correction values, and some of the ballistic software we’re going to discuss will help make that correction in your dope.

Let’s take a look at each of these factors in depth.

CHAPTER 8
GRAVITY

If you’ve ever accidently dropped a drinking glass while doing the dishes, the resulting shards are a result of good ol’ gravity. Earth has a definite force known as gravity, which pulls all objects toward its center whether at rest or in motion. All objects, if we ignore the effects of atmospheric resistance, fall to the ground at the same speed. Yes, there are minute variations, but for our purpose of

understanding the trajectory of a projectile assume that all bullets are going to be drawn toward the planet’s center at the same rate. The same rate, in fact, as if you simply held them against the muzzle and let them fall to the ground (this would be absolute in a vacuum, but it’s close enough for this discussion, the atmospheric forces actually tend to give a bullet in flight a tiny bit of lift.)

In order to reach a distant target, you must propel the projectile from your barrel at a certain speed, in order to cover more horizontal distance before the gravitational pull brings it down to the

ground. Otherwise, you’d be resorting to climbing trees and dropping heavy rocks on your prey from above, and that’s not much fun at all. So, assuming a standard, uniform projectile, whether a sleek spitzer boat tail or a round ball fired from a muzzleloader, the faster the projectile is launched, the more horizontal distance it will cover. Let’s look at an example.

Imagine a projectile launched from the muzzle of a rifle at dead level, perpendicular to the gravitational force, and launched at a velocity of 2,000 fps. It would cover a certain amount of distance,

which we’ll call X, before it falls to the earth, yet will fall at the same rate as if you had dropped it. Now imagine the same projectile launched at 3,000 fps. It, too, will fall at the same prescribed rate, but will cover a different amount of distance, call it Y. It’s rather plain to see that the ‘X’ distance (of the slower bullet) must be less than the ‘Y’ distance due to the latter’s greater speed. The faster you propel a bullet (assuming the weight and dimensions are uniform), the more ground it will cover before dropping to the earth.

This is the very reason magnum cartridges give a ‘flatter’ trajectory than do their standard velocity counterparts: the bullet is simply moving faster and covers more ground in the time it takes gravity to pull it downward.

When you use a firearm, you are never perfectly aligning the bore to the line of sight. You are constantly fighting the effects of the gravitational force, and must therefore elevate the muzzle of the firearm with respect to the line of sight, giving the bullet’s trajectory some amount of arc. Most of the time, your

sight plane is above the bore (laser-sighted handguns are the only exception I can think of), so the bullet starts out at a certain distance below the bore from the word go. Once the powder is burned and the bullet leaves the muzzle it will cross the sight plane at a certain distance — typically 25 to 30 yards for rifle bullets — then rise above the sight plane only to cross that plane again at the zero distance.

It is the second crossing of the sight plane, the zero distance, which you use to reference your trajectory curve. When we

say that a rifle is ‘zeroed’ for 200 yards, it means that the bullet will cross the line of sight at exactly 200 yards. Within that distance, there will be a slight rise, the amount depending on the shape and velocity of the bullet. Past the ‘zero’ distance the parabolic curve is generated by the slowing of the bullet and the effects of gravity, and represents a trajectory that will show how the bullet will drop.

One of my favorite big game cartridges is the .300 Winchester Magnum, and my best load for that rifle pushes a 180-grain

Swift Scirocco II bullet at a velocity of 2,960 fps. I use a 200-yard zero for this rifle, as that best serves my needs for most of my hunting situations. Once I plug the data into the Hornady Ballistic Calculator (www.Hornady.com) the trajectory is as follows. The bullet starts out at 1.75 inches below the sighting plane (a Leupold riflescope), and first crosses the line of sight at about 30 yards. Remember, I have sighted this rifle to have the bullet hit spot-on the bullseye at 200 yards, so there will be some elevation between 40 yards and 200

yards. The highest that bullet will rise in its trajectory curve is 1.6 inches at 125 yards.

The author’s .300 Winchester Magnum, in a Model 70 Classic Stainless, with 180-grain Scirocco II bullet.

RANGE(YARDS)	VELOCITY(FPS)	ENERGY(FT.-LB.)	TRAJECTORY(IN)
Muzzle	2,960	3,502	-1.75
50	2,868	3,288	0.5
100	2,779	3,086	1.5
150	2,691	2,894	1.4
200	2,605	2,712	0
250	2,521	2,540	-2.6
300	2,438	2,375	-6.6
350	2,357	2,220	-12.1
400	2,277	2,072	-19.1
450	2,198	1,932	-27.8
500	2,122	1,799	-38.3
550	2,046	1,674	-50.8
600	1,973	1,555	-65.3
650	1,901	1,444	-82.1
700	1,831	1,339	-101.2
750	1,762	1,241	-123
800	1,696	1,149	-147.5
850	1,631	1,063	-175.1
900	1,569	984	-205.9
950	1,509	910	-240.3
1000	1,451	842	-278.5

View a text version of this table

Downhill shooting requires an adjustment in trajectory.

Once it crosses the sighting plane again at 200 yards, it begins to drop below the line of sight. At 250 yards, the bullet will strike 2.6 inches below the line of sight, and at 300 yards it has dropped 6.6 inches. Take it out a bit farther, and

you'll find it dropped 12.1 inches at 350 yards, 19.1 at 400 yards, and 27.8 at 450 yards. At extreme ranges, you'll get a feel for how quickly trajectory drops off. At the 600-yard mark, the bullet drops 65 inches, and at 700 yards a full 101 inches. You can easily see why it is difficult to hit those distant targets! Now, the .300 Winchester Magnum is considered a 'flat shooting' cartridge, yet even this trajectory requires a precise knowledge of the distance to the target when shooting past 200 yards. Because I use this rifle for hunting, I can accept a vertical deviation

of about 2.5 inches up or down and still be confident in striking the vitals of a game animal, so I will call this rifle “dead-on” to 250 yards; meaning that my bullet will neither rise nor fall more than 2.5 inches from the line of sight.

Once distances exceed 250 yards, the effect of gravitational pull forces me to make an adjustment in my sighting plane, to account for the bullet’s drop. There is plenty of good, accurate data available to predict the effect of gravitational pull, and if you intend to shoot at distances past the point at which your rifle is

zeroed I'd highly recommend you take a look at it.

ANGLE SHOOTING

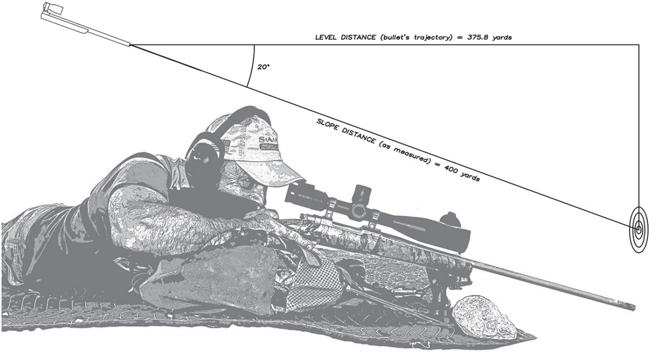
All of these figures I've shown you are relative to a flat-shooting plane, where the muzzle and target are at the same elevation. If you raise or lower the target, the amount of drop necessary will appear to change. Let's say I'm using my .300 Winchester to shoot at a target 400 yards away, but at a downhill angle of 20 degrees. The above information will indicate that I need to hold 19.1 inches above the bullseye, in order to allow for

the drop over that distance. However, I’d hit the target about 4 inches higher than I aimed. Now, perhaps that would still be a lung hit, or maybe it would not be a vital hit at all. Why?

When measuring the effect of gravity on a bullet’s trajectory, it needs to be done on a level line, perpendicular to the line of gravity. When shooting uphill or down, you need to know the level distance. It’s not hard to calculate this difference; simply observe the angle of deviation from level (in our instance, 20 degrees), and take the cosine of that

angle. Multiply those results by the slope distance (like you'd observe on some laser range finders) and you'll have the level distance. In the case above, where my .300 Winchester was 19.1 inches low at 400 yards, I should've held for 375 yards — the level distance — where the bullet will strike 15.5 inches low. Here's the math:

SLOPE SHOOTING



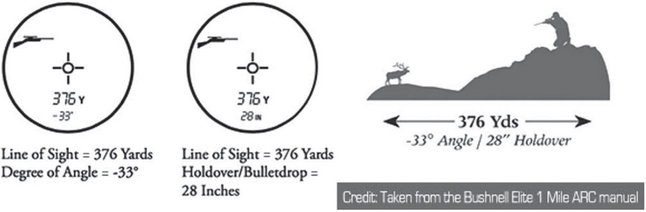
Many smartphones offer an app for measuring slope angle.

Cos (20 deg.) = 0.939 0.939 x 400 yards = 375.8 yards.

As the shooter, you need to know both the distance (again the range finder is your friend), and angle, either up or down. There are a couple of methods I recommend. Many of today’s smartphones provide an app that will act as a level, providing a measurement of the angle up or down from level; I use one that acts as a clinometer (I’m a mild-mannered land surveyor by day) and is rather accurate. If I have a severe uphill

or downhill shot, especially at the distances where the reduction in range becomes significant, I should have time to use my phone to observe the angle and make the necessary adjustment. Many of today’s laser rangefinders, such as the Bushnell Elite 1 Mile, also provide either a level distance to the target, doing the mathematics for you, or will provide the angle from the shooter to the target. If you don’t like the electronic gizmos, you can spend some time in the field judging some severe slopes where the level distance to the target will be affected

most, and develop a good idea of what a 10-degree slope looks like in comparison to a 20- or even 30-degree slope. When things get to 30 degrees and more, you’ll usually find climbing requires a hands and knees position. It’s very common for most folks to judge a slope as more severe than it truly is, so some practice will come in handy for reducing those distances to level. While few of us carry a cosine chart around in our heads, here’s a good reference piece to give you the amount of reduction necessary, in percentages.



The Bushnell 1 Mile rangefinder helps establish the shooting angle.

5-10 degree slope = 98% of slope distance

15-20 degree slope = 95% of slope distance

25-30 degree slope = 90% of slope distance

35-40 degree slope = 80% of slope distance

45 degree slope = 70% of slope distance

For the rifle, where we have the benefit of using sleek, sharp bullets that resist gravity’s effects efficiently, the gravitational drop is a manageable figure, especially within common hunting distances. For the handgun hunter, where velocities are significantly lower — coupled with using projectiles that traditionally have a much lower BC —

knowing the distances even within 150 yards becomes paramount.

For personal defense guns, the distances at which you are likely to shoot are close enough to negate the major effects of gravitational pull. That said, I like to take my carry guns out to distances where I see a definite drop in my group, so I know what's going on. The same principals we discussed for rifle bullets apply to handgun bullets, except the scale shrinks a bit.

As a side note, while all of this mathematical wizardry probably won't

make much of a difference to the hunter whose shots are taken within 200 yards (which I feel represents a great deal of the shots taken at game annually), there is a movement in the hunting world to take shots at game at distances that seem to increase with every television season. While I realize that shots out past 500 yards can certainly be executed by a shooter who is highly experienced and knows his or her gear inside and out, the portrayal of routine shots taken out past 700 yards, at unwounded game, is not only unethical, but will result in a

multitude of wounded game. As I demonstrated with the drop figures alone — saying nothing of the effects of wind deflection — a misjudgment in distance of as little as 25 yards can result in a wounded and/or lost animal. I highly suggest you find your own personal limits with respect to distance, based upon your own shooting abilities, and stay true to that figure. It’s one of the instances where you’ll have to police yourself. Should you realize that the distance is too great to make a confident hit, simply say no to the shot and get

closer. Purchasing the best long range optics, and a cartridge/rifle combination that is theoretically capable of connecting, does not make it a wise decision to take the shot. I don’t want to sound like I’m preaching, but I’m not comfortable with the way some outdoor personalities act blasé about shots past 500 yards at game; there’s an awful lot that can go wrong.

So, with an accurate drop chart available, how can you make those shots that require a certain amount of holdover? Gravity is relentless, and you

need to fight that effect, even at 250 or 300 yards.

In this great technological age you'd be foolish not to take advantage of electronic calculators. A ballistic drop compensated (BDC) reticle in a riflescope is another means. This is a reticle with more than just crosshairs, but a series of smaller horizontal lines on the lower vertical wire at a predetermined interval, providing a specific aiming point out at certain distances. For example, my 6.5-284 Norma wears a Swarovski Z5 3.5-18x44mm riflescope,

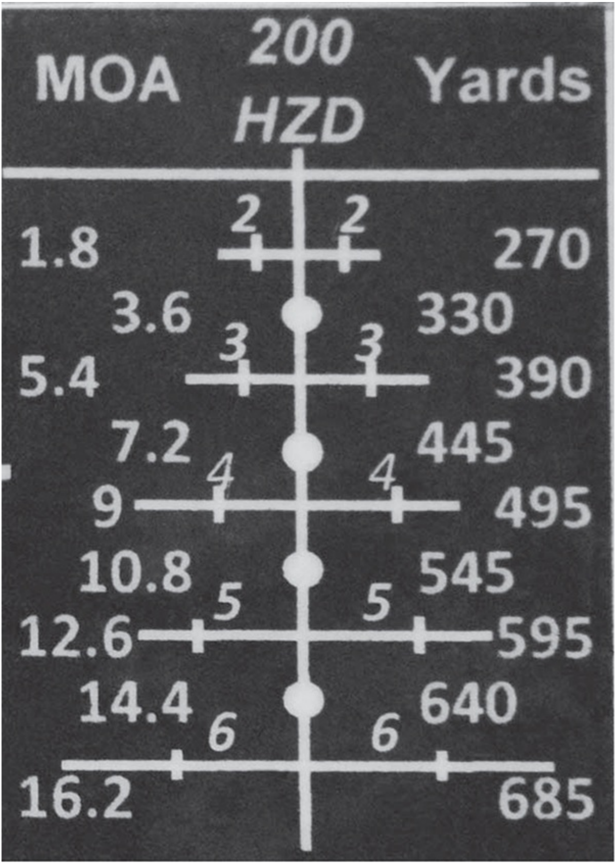
with the BRH reticle. This optic features a duplex reticle on three of the four wires (up, left and right) and a ballistic compensated reticle on the lower vertical wire. In addition to the crosshair point, which I use for a 200-yard zero, there are five additional, smaller crosswires, and four small dots on that lower wire, as well as a point where the thin wire thickens. In that rifle with 140-grain handloads, it works like this: my traditional crosshair is set to hit at 200 yards (and at any range shorter than that I’ll confidently hit an animal’s vitals),

using the next lower crosswire it will hit at 270 yards, and the dot below that will impact at 330 yards. Should an even 300-yard shot present itself, I simply hold between the first crosswire and first dot.

Holding at the next crosswire down causes the rifle to hit at 390 yards (I use this for 400, calling it close enough) while the next dot lower is for 450 yards. Continuing down the line, the next line is an even 500 yards, and the dot below that will strike at 550 yards. The fourth wire down strikes at 590 yards (so close to 600 it'll scare you) and the dot below impacts

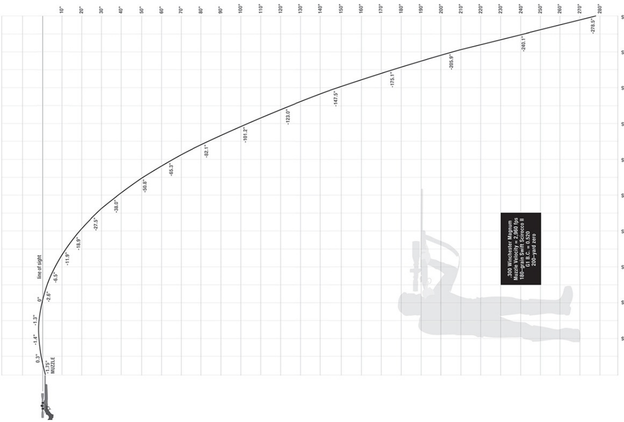
at 640 yards. The lowest crosswire is designed to hit at 680 yards, but we’re already considerably past my hunting ranges. I much prefer to stay within 400 yards, but certain hunts may require a longer shot. However, it sure is fun to play with steel plates and paper targets at those distances. Now, I’ve found this reticle works within reason at these distances, and Swarovski has put a considerable amount of research into it. And while this is only one of their available options, I think it makes a good choice for a hunter whose ranges concur

with my own, or don’t plan to take shots much past 600 yards (where things can get tricky due to the winds, but that’s for later).



MOA
200
HZD
Yards
2
2
1.8
270
3.6
330
3
3
5.4
390
7.2
445
4
4
9
495
10.8
545
5
5
12.6
595
14.4
640
6
6
16.2
685

The author’s dope card for the Swarovski Z5 reticle.



The projection for the author’s .300 Winchester load out to 1,000 yards.

The dial-up method requires an intimate knowledge of your riflescope, but becomes second nature quickly.

A good laser rangefinder is an invaluable tool for shots that require a specific amount of holdover.

TRUST THEN VERIFY

However well your trajectory projections are, you must verify your point of impact v. point of aim in actual field conditions. This is called truing the rifle, and it’s an important part of knowing how your measuring device (reticle) works at extended ranges. While Swarovski has done an exorbitant amount of homework, barrels are finicky little buggers, and slight variations of barrel performance or ammunition can result in a different distance at which those crosswires and dots will strike. Swarovski provides several blank

stickers, with a reticle diagram, for those who perhaps shoot a cartridge/bullet combination that doesn’t mate up to one of the standard profiles, or for those who wish to tweak and fine-tune the reticle measurements. After all, those crosswires are nothing more and nothing less than a series of reference points for holds on distant shots, rather than the “hold the top of the back and send it” method. Note, because this reticle works in the second focal plane, these measurements will only work when the riflescope is at maximum power, in my case at 18x. By the way,

those small crosswires each have a vertical tick mark to demonstrate 10 and 20 mph crosswinds, but that’s another discussion that will be handled in an upcoming chapter.

Another method that is frequently employed for hitting distant targets is to ‘dial-up’ the elevation turret the required amount to move the crosshairs to the necessary point of aim. These are the riflescopes with the huge turrets, replete with finger grooves for quick turning. They are designed to quickly dial an elevation change, based upon a dope card

that matches your particular ammunition. For example, if you zero a rifle such as my .300 Winchester Magnum at 200 yards, the elevation drop for further distances can be compensated for by dialing up a particular amount of minutes of angle, or a particular amount of milliradians, or mils on the elevation turret. Again, an example:

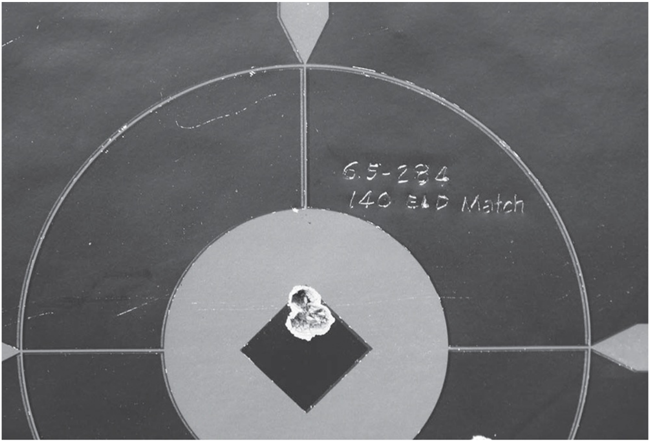
When I hand you my favorite .300 Winchester, you take a few shots at the 200-yard target and verify it hits the bullseye. You are then presented with a shot at 450 yards, and are forced to use

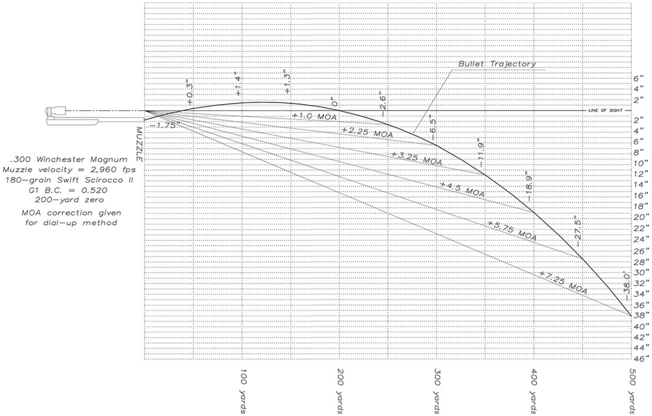
only the elevation turret to make the adjustment, so as to hold the crosshairs directly on the target in order to make the shot. Consulting the same ballistic chart you did earlier, you would see that the Hornady program says you’d need an additional 5.9 MOA in order to have your trajectory curve strike the line of sight at 450 yards. Assuming you set the elevation turret to read zero when you hit the 200-yard bullseye, it would be a simple adjustment of dialing up to 6.0 MOA (rounding the 5.9 up to 6.0, as the scope takes adjustment in 0.25 MOA

increments), and a confident, yet gentle squeeze of trigger to make a solid hit. Using this ‘dial-up’ method is a quick learning curve, allowing you all sorts of flexibility if you know the range. This method, as well as the Ballistic Drop Compensated reticle, requires a definitive knowledge of the range at which you are shooting, or all is for naught.

The distance to the target, whether sloped or level, is a required variable in the equation of holdover to defeat gravitational force. A good laser rangefinder is a very important piece of

gear to the hunter or shooter who needs to make that distant shot on a target at an unknown distance. In addition, ‘measuring’ reticles can also be used to approximate distance, if the size of the game animal is known.





.300 Winchester Magnum
Muzzle velocity = 2,960 fps
180–grain Swift Scirocco II
G1 B.C. = 0.520
200–yard zero
MOA correction given
for dial–up method
Bullet Trajectory
LINE OF SIGHT
MUZZLE
–1.75"
+0.3"
+1.4"
+1.3"
0"
–2.6"
–6.5"
–11.9"
–18.9"
–27.5"
–38.0"
+1.0 MOA
+2.25 MOA
+3.25 MOA
+4.5 MOA
+5.75 MOA
+7.25 MOA
6"
4"
2"
2"
4"
6"
8"
10"
12"
14"
16"
18"
20"
22"
24"
26"
28"
30"
32"
34"
36"
38"
40"
42"
44"
46"
100 yards
200 yards
300 yards
400 yards
500 yards

At any rate, the effects of gravity are predictable, and can be compensated for. Of all the effects that will be placed upon a bullet once it's launched from the barrel, gravitational pull is the easiest with which to deal. However, your

riflescope’s reticle must be perfectly aligned with the centerline of your rifle’s bore. Any sort of a cant in the alignment of the vertical hair, and your bullets will not drop in a line along the vertical crosshair, they will be hitting in the direction that the top of the scope is canted. This can be frustrating, especially with an accurate rifle that *should* be hitting where you aim. I highly recommend a scope level; there are many styles available, and they can be an invaluable tool for long-range work, ensuring that your bullets fall along the

line of the vertical crosswire. If you keep things precise before you pull the trigger, it will become much easier to hit a distant target.

CHOOSING A ZERO

At what distance you choose to zero your rifle is both subjective and personal. Different hunting or shooting scenarios call for different zero distances. Firstly, where do you hunt? Is it in the thick forests of the northern West Coast, or the arboreal forests of the Northeast, where most of your shots are within 100 paces? Or are you a Western hunter, where shots

can vary from up-close-and-personal to across a distant canyon? All of these situations call for a different zero, and you should look at some of the reasons for the choice.

The .30-30 Winchester is a great woods cartridge for deer-sized game.

Starting with a woods gun, like a .30-30 Winchester, it really wouldn't make sense to set the zero at 200 yards, like

you would with many of the common centerfire rifle cartridges. That’s because the severe arc of its trajectory would cause a rise of 4.2 inches at 100 yards, which is a bit much in thick vegetation. More sensible would either be a 100-yard zero, which is actually about the longest shot you’re likely to get in the woods anyhow, or at best a 150-yard zero if you’re concerned about a longer shot.

FROM THE FEDERAL PREMIUM BALLISTICS CALCULATOR:

Load Number:	3030B
Zero Range:	75 yd.
Caliber:	.30-30 Win.
Temperature:	59 °F
Bullet Style:	Soft Point RN
Wind Speed:	10 mph
Bullet Weight:	170 gr.
Altitude:	0 feet
Ballistic Coefficient:	0.254
Max Range:	300 yd.
Muzzle Velocity:	2200 fps
Test Barrel:	24 in.
Sight Height:	1.5 in.

Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
0	-1.5	0.0	2,200	1,827
25	0.1	0.1	2,121	1,698
50	1.2	0.4	2,044	1,577
75	1.8	1.0	1,968	1,462
100	1.8	1.8	1,894	1,354
125	1.3	2.9	1,822	1,253
150	0.0	4.3	1,753	1,159
175	-2.0	6.1	1,685	1,072
200	-4.7	8.1	1,619	990
225	-8.2	10.4	1,556	913
250	-12.6	13.0	1,494	843
275	-18.0	16.0	1,435	777
300	-24.5	19.4	1,380	719

View a text version of this table

This kind of scenario is pretty close to the old “inch-and-a-half-high-at-a-hundred” recommendation to which my grandfather subscribed. He felt it covered all the bases, and it does. I actually prefer

to zero my .30-30 Winchester at 75 yards, because that’s about the longest shot I get in the areas I most frequently use my old lever gun to hunt. My trajectory looks more like this, again from Federal:

FROM THE FEDERAL PREMIUM BALLISTICS CALCULATOR:

Load Number:	3030B
Zero Range:	75 yd.
Caliber:	.30-30 Win.
Temperature:	59 °F
Bullet Style:	Soft Point RN
Wind Speed:	10 mph
Bullet Weight:	170 gr.
Altitude:	0 feet
Ballistic Coefficient:	0.254
Max Range:	300 yd.
Muzzle Velocity:	2200 fps
Test Barrel:	24 in.
Sight Height:	1.5 in.

Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
0	-1.5	0.0	2,200	1,827
25	-0.5	0.1	2,121	1,698
50	0.0	0.4	2,044	1,577
75	0.0	1.0	1,968	1,462
100	-0.5	1.8	1,894	1,354
125	-1.7	2.9	1,822	1,253
150	-3.6	4.3	1,753	1,159
175	-6.1	6.1	1,685	1,072
200	-9.5	8.1	1,619	990
225	-13.6	10.4	1,556	913
250	-18.6	13.0	1,494	843
275	-24.5	16.0	1,435	777
300	-31.6	19.4	1,380	719

View a text version of this table

Federal's Trophy Bonded Tipped .308 Winchester load.

While I may be 6 inches low at 175 yards, I don't feel comfortable taking a shot at that distance with an iron-sighted carbine anyhow, so I prefer the one-inch

window trajectory. That way I don’t have to think about drop at all, within ‘woods range.’

Let’s look at a .308 Winchester, with a bit more muzzle velocity, and a bullet that has a form better suited to the longer ranges. I generally zero a rifle in this class at 200 yards; that gives me a dead hold to somewhere around 250 yards on a deer-sized target. Let’s look at the Federal Trophy Bonded Tipped factory load, at 165-grains.

FROM THE FEDERAL PREMIUM BALLISTICS CALCULATOR:

Load Number:	P308TT4
Zero Range:	200 yd.
Caliber:	.308 Win. (7.62x51mm)
Temperature:	59 °F
Bullet Style:	Trophy Bonded® Tip
Wind Speed:	10 mph
Bullet Weight:	165 gr.
Altitude:	0 feet
Ballistic Coefficient:	0.45
Max Range:	500 yd.
Muzzle Velocity:	2880 fps
Test Barrel:	24 in.
Sight Height:	1.75 in.

Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
0	-1.8	0.0	2,880	3,039
25	-0.5	0.0	2,828	2,929
50	0.5	0.2	2,776	2,823
75	1.2	0.4	2,725	2,721
100	1.6	0.7	2,675	2,621
125	1.6	1.1	2,625	2,524
150	1.4	1.6	2,575	2,430
175	0.9	2.2	2,527	2,339
200	0.0	2.9	2,478	2,250
225	-1.2	3.6	2,431	2,164
250	-2.8	4.5	2,383	2,081
275	-4.8	5.5	2,337	2,000
300	-7.2	6.7	2,290	1,922
325	-10.0	8.0	2,245	1,846
350	-13.3	9.3	2,200	1,773
375	-17.0	10.8	2,155	1,701
400	-21.1	12.5	2,111	1,633
425	-25.8	14.2	2,067	1,566
450	-30.9	16.0	2,024	1,501
475	-36.6	18.1	1,982	1,439
500	-42.6	20.1	1,939	1,377

View a text version of this table

Again, you see the "inch-and-a-half-high-at-a-hundred," with a respectable

trajectory at the longer hunting ranges. What if you wanted to flatten the trajectory a bit, by using a 250-yard zero? What would that do to your closer shots? Here’s the dope:

BALLISTICS CALCULATOR:

Load Number:	P308TT4
Zero Range:	250 yd.
Caliber:	.308 Win. (7.62x51mm)
Temperature:	59 °F
Bullet Style:	Trophy Bonded® Tip
Wind Speed:	10 mph
Bullet Weight:	165 gr.
Altitude:	0 feet
Ballistic Coefficient:	0.45
Max Range:	500 yd.
Muzzle Velocity:	2880 fps
Test Barrel:	24 in
Sight Height:	1.75 in

Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
0	-1.8	0.0	2,880	3,039
25	-0.2	0.0	2,828	2,929
50	1.0	0.2	2,776	2,823
75	2.0	0.4	2,725	2,721
100	2.7	0.7	2,675	2,621
125	3.1	1.1	2,625	2,524
150	3.1	1.6	2,575	2,430
175	2.9	2.2	2,527	2,339
200	2.2	2.9	2,478	2,250
225	1.3	3.6	2,431	2,164
250	0.0	4.5	2,383	2,081
275	-1.7	5.5	2,337	2,000
300	-3.8	6.7	2,290	1,922
325	-6.4	8.0	2,245	1,846
350	-9.3	9.3	2,200	1,773
375	-12.8	10.8	2,155	1,701
400	-16.6	12.5	2,111	1,633
425	-21.0	14.2	2,067	1,566
450	-25.8	16.0	2,024	1,501
475	-31.2	18.1	1,982	1,439
500	-37.0	20.1	1,939	1,377

View a text version of this table

The highest point in the mid-range trajectory is 3.1 inches, which is

tolerable, especially on an open country hunt. This bullet travels to lower than 3 inches out to 290 yards. Considering the size of a deer’s vital area, that represents a dead hold out to 300 yards. I know that the Federal Premium load develops a rather high muzzle velocity, but it is legitimate, so when you’re shooting a .308 Winchester you have a solid big-game cartridge.

There are times when I use a 100-yard zero with my .308, especially when hunting in the thicker wooded areas of Upstate New York when I need to ‘thread

the needle' on those tight shots. But, I need to know what will happen on the longer shots, even if it's just out to 200 or 250 yards. Here's that same load with a 100-yard zero:

BALLISTICS CALCULATOR:

Load Number:	P308TT4
Zero Range:	100 yd.
Caliber:	.308 Win. (7.62x51mm)
Temperature:	59 °F
Bullet Style:	Trophy Bonded® Tip
Wind Speed:	10 mph
Bullet Weight:	165 gr.
Altitude:	0 feet
Ballistic Coefficient:	0.45
Max Range:	500 yd.
Muzzle Velocity:	2880 fps
Test Barrel:	24 in.
Sight Height:	1.5 in.

Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
0	-1.5	0.0	2,880	3,039
25	-0.7	0.0	2,828	2,929
50	-0.2	0.2	2,776	2,823
75	0.1	0.4	2,725	2,721
100	0.0	0.7	2,675	2,621
125	-0.4	1.1	2,625	2,524
150	-1.0	1.6	2,575	2,430
175	-2.0	2.2	2,527	2,339
200	-3.4	2.9	2,478	2,250
225	-5.0	3.6	2,431	2,164
250	-7.1	4.5	2,383	2,081
275	-9.5	5.5	2,337	2,000
300	-12.4	6.7	2,290	1,922
325	-15.6	8.0	2,245	1,846
350	-19.4	9.3	2,200	1,773
375	-23.5	10.8	2,155	1,701
400	-28.1	12.5	2,111	1,633
425	-33.2	14.2	2,067	1,566
450	-38.7	16.0	2,024	1,501
475	-44.9	18.1	1,982	1,439
500	-51.4	20.1	1,939	1,377

View a text version of this table

Let’s bump things up to the magnum class cartridges with a look at the .300

Winchester Magnum, loaded with the same 165-grain Trophy Bonded Tip, and a 250-yard zero.

BALLISTICS CALCULATOR:

Load Number:	P300WTT2
Zero Range:	250 yd.
Caliber:	.300 Win. Magnum
Temperature:	59 °F
Bullet Style:	Trophy Bonded® Tip
Wind Speed:	10 mph
Bullet Weight:	165 gr
Altitude:	0 feet
Ballistic Coefficient:	0.45
Max Range:	500 yd.
Muzzle Velocity:	3050 fps
Test Barrel:	24 in.
Sight Height:	1.5 in.

Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
0	-1.5	0.0	3,050	3,408
25	-0.1	0.0	2,996	3,288
50	1.0	0.1	2,942	3,171
75	1.8	0.3	2,889	3,058
100	2.4	0.6	2,837	2,948
125	2.8	1.0	2,785	2,841
150	2.8	1.5	2,734	2,738
175	2.6	2.0	2,683	2,638
200	2.0	2.7	2,633	2,540
225	1.2	3.4	2,584	2,446
250	0.0	4.2	2,535	2,354
275	-1.5	5.2	2,487	2,265
300	-3.4	6.1	2,439	2,179
325	-5.6	7.2	2,391	2,095
350	-8.2	8.5	2,345	2,014
375	-11.2	9.9	2,298	1,935
400	-14.6	11.4	2,253	1,859
425	-18.5	13.0	2,207	1,785
450	-22.8	14.7	2163	1713
475	-27.6	16.6	2,118	1,644
500	-32.8	18.5	2,075	1,577

View a text version of this table

The trajectory flattens out, from the increased muzzle velocity. In comparing

the trajectory between the .308 Winchester and .300 Winchester Magnum, it may not seem that there is a huge advantage given to the magnum, but realize that the .308 load is hot (about 125 fps higher than standard), and the .300 Magnum load is a standard velocity. It pays to seek out the faster loads, if you want the most out of a standard rifle.

Let’s look next at the .300 Remington Ultra Magnum, in the Federal Trophy Bonded Tip, but switch to the heavier 180-grain bullet. The 180 grainer will

maximize the additional muzzle velocities.

BALLISTICS CALCULATOR:

Load Number:	P300RUMTT1
Zero Range:	250 yd.
Caliber:	.300 Rem. Ultra Magnum
Temperature:	59 °F
Bullet Style:	Trophy Bonded® Tip
Wind Speed:	10 mph
Bullet Weight:	180 gr.
Altitude:	0 feet
Ballistic Coefficient:	0.5
Max Range:	500 yd.
Muzzle Velocity:	3200 fps
Test Barrel:	24 in.
Sight Height:	1.5 in.

Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft-lb)
0	-1.5	0.0	3,200	4,092
25	-0.3	0.0	3,149	3,964
50	0.7	0.1	3,099	3,839
75	1.5	0.3	3,050	3,717
100	2.1	0.5	3,001	3,599
125	2.4	0.8	2,952	3,484
150	2.4	1.2	2,905	3,372
175	2.2	1.6	2,857	3,263
200	1.8	2.2	2,810	3,157
225	1.0	2.8	2,764	3,053
250	0.0	3.5	2,718	2,953
275	-1.3	4.3	2,673	2,855
300	-3.0	5.2	2,628	2,760
325	-4.9	6.1	2,584	2,668
350	-7.1	7.1	2,540	2,578
375	-9.8	8.3	2,496	2,490
400	-12.6	9.4	2,453	2,404
425	-15.9	10.7	2,410	2,321
450	-19.6	12.1	2,368	2,240
475	-23.7	13.6	2,326	2,162
500	-28.2	15.2	2,284	2,085

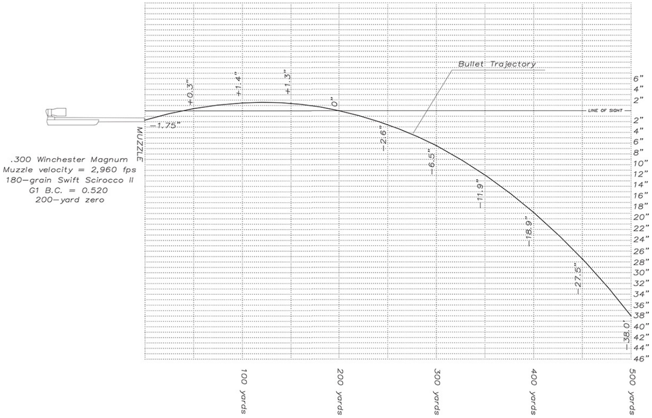
View a text version of this table

Even with the heavier bullet, the .300 RUM offers the flattest trajectory of all,

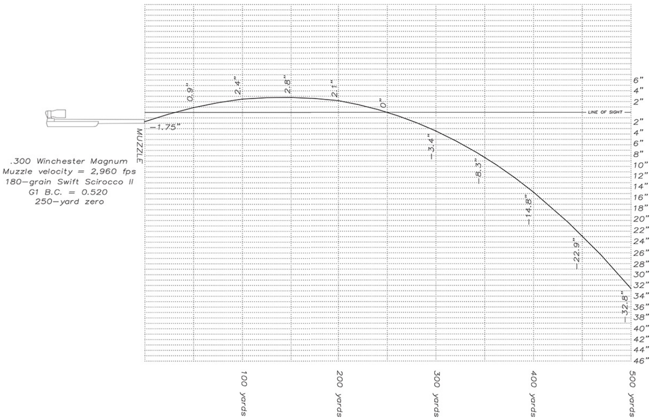
and is definitely worthy of the 250-yard zero. It’s a dead hold to 300 yards.

Personally, if I were rockin’ a .300 RUM, I’d opt for a 275-yard zero, for this trajectory curve. It would be the optimum curve for long-range big game hunting. It’d look like this:

The .300 Remington Ultra Magnum.



Example of how changing the zero on the author's .300 Winchester Magnum affected its long-range trajectory.



Example of how changing the zero on the author's .300 Winchester Magnum affected its long-range trajectory.


ODEL 1 XP CHRONOGRAPH
START STRING
REVIEW EDIT
AMMUNITION

BALLISTICS CALCULATOR:

Load Number:	P300RUMTT1
Zero Range:	275 yd.
Caliber:	.300 Rem. Ultra Magnum
Temperature:	59 °F
Bullet Style:	Trophy Bonded® Tip
Wind Speed:	10 mph
Bullet Weight:	180 gr.
Altitude:	0 feet
Ballistic Coefficient:	0.5
Max Range:	500 yd.
Muzzle Velocity:	3200 fps
Test Barrel:	24 in.
Sight Height:	1.5 in.

Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft-lb)
0	-1.5	0.0	3,200	4,092
25	-0.2	0.0	3,149	3,964
50	1.0	0.1	3,099	3,839
75	1.9	0.3	3,050	3,717
100	2.6	0.5	3,001	3,599
125	3.0	0.8	2,952	3,484
150	3.2	1.2	2,905	3,372
175	3.1	1.6	2,857	3,263
200	2.7	2.2	2,810	3,157
225	2.1	2.8	2,764	3,053
250	1.2	3.5	2,718	2,953
275	0.0	4.3	2,673	2,855
300	-1.5	5.2	2,628	2,760
325	-3.3	6.1	2,584	2,668
350	-5.4	7.1	2,540	2,578
375	-7.9	8.3	2,496	2,490
400	-10.7	9.4	2,453	2,404
425	-13.9	10.7	2,410	2,321
450	-17.4	12.1	2,368	2,240
475	-21.4	13.6	2,326	2,162
500	-25.7	15.2	2,284	2,085

View a text version of this table

Assuming a 6-inch vital zone, I’m all set to about 325 yards, with the heavier

bullet giving me additional energy thanks to the huge RUM case.

You can see how changing the zero of your rifle can be an important means of optimizing the performance of a particular load, and how different hunting situations may require an adjustment of your scope. Once you find a type of factory ammunition or handload that gives you the accuracy you’re after, simply plug it into one of the ballistic calculators to see what zero will work best for your hunting situation. Just remember, you need to keep an eye on

what happens between the muzzle and the zero distance, so that a 100- or 125-yard shot doesn’t hit too high. Keep things within two or three inches above the line of sight, and you should be good to go.

CHAPTER 9
BALLISTIC COEFFICIENT

Explaining ballistic coefficient, or BC is no easy task. The bullet companies publish a listed BC value for their projectiles, but how is it determined? I turned to the sage wisdom of a dear friend of mine, Robin Sharpless of Redding Reloading. Sharpless has had a distinguished career in the firearms industry, having helped develop the

CheyTac line of cartridges and projectiles. I asked him to prepare a dissertation on ballistic coefficient and its influences.

BC: ART, SCIENCE AND ALCHEMY | BY ROBIN SHARPLESS

The list of searchable definitions of ballistic coefficient is long and truly quite diverse. It deals with drag, slipperiness, ease of the bullet’s movement through air. Historically, it was defined through the variance of velocity of a bullet at two specific distances. That is a static approach, which only really gives you an indication over that distance and under those conditions.

From Wikipedia: (n) ballistics, the ballistic coefficient (BC) of a body is a

measure of its ability to overcome air resistance in flight. It is inversely proportional to the negative acceleration — a high number indicates a low negative acceleration. This is roughly the same as saying that the projectile in question possesses low drag, although some meaning is lost in the generalization. BC is a function of mass, diameter, and drag coefficient.

There are literally hundreds of articles and variations of BC formulas available today. The bottom line in all of this is not so much to rate one bullet against another

for a higher value. The true value to the hunter is the ability to predict where that bullet will end up based on velocity, wind, barometric pressure, humidity, slant angle and a host of other factors when trying to humanely take a game animal at a distance. BC is the critical driver in all ballistic software and can in itself thumbnail one bullet over another for this crazy concept of relational negative acceleration.

Actually, BC was derived from U.S. Military research long, long ago and the coefficient is a comparison to a specific

fictitious projectile used at that time. This is the basis of the G1 BC model. Years later, a more efficient boat tail bullet was used as the basis for comparison creating the G7 Model that we see today. In either case, you are comparing to a fictitious projectile at the time.

Your real interest in ballistic coefficients is to use them as a basis in conjunction with either software or mathematical calculations to predict where a projectile at a given speed with a given ballistic coefficient will be at the end of its flight to target. You add to this

a variety of other environmental and physical factors that affect the bullet’s flight to create a set of adjustments for your optical sighting device. This allows you to correct for all of the variables, including BC, and with some measure of luck (hence the alchemy term) to score solid hits on the target.

Time and technology have changed and the advent of high-speed Doppler radar units and heavy-duty computing power for backend processing has shown us a very different view of BC. Today, it is not simply a measure of how the bullet

travels through the air under varying circumstances and conditions. We’ve learned that BC is not a constant, but a variable with some basis in velocity and a host of other impacting factors. Today we know that the BC as a constant model is false as the actual slipperiness (BC) of the projectile changes at varying velocities throughout its flight profile.

My experience with this came during a time when I was involved with an advanced sniper weapons system company and we used the high-speed Doppler units at both the Yuma and

Aberdeen proving grounds to develop the firm’s ballistic computer system and prove the concept behind a radical (for the time) new projectile. The Doppler radar units showed us BC in as little as 1-yard increments over 3,500 yards of flight. It also showed us the real effects of *precession*, that is, how the bullet’s nose climbs up into the wind with a specific twist rotation and wind resistance on the nose of the bullet. Further, it allowed us to see the true effect of over-stabilization in the early flight of the bullet and its

highly degrading effect on the potential BC of a specific bullet.

BC AS A TRANSITORY FUNCTION OF VELOCITY

Historically, BC was calculated from a pair of velocities over a specified distance and the change, or delta, which occurred. As time progressed, refinements were added for air pressure and other variables. The difficulty here is that the velocity data was derived only from the change that occurred within a given distance and range of velocities. One chronograph at the muzzle and

another at a given range would produce two velocity readings that would be used with a formula to determine a numerical BC value based on one of the existing models. However, the work done on the Doppler radar has shown the flaw in a static BC model. This becomes a larger and larger problem as distance increases. BC changes with velocity and, therefore, a static number becomes a greater negative in predictive capability for shots at longer distances.

Marines work as a sniper-spotter team to assess targets down range using the M110 Semi-Automatic Sniper System.

The best ballistic computer systems now work with velocity respective sets of BC values and are providing far better predictive capabilities at long range.

PRECESSION

As mentioned, precession is the term for the nose of the bullet climbing up and into a wind based off of the rotational energy. Doppler radar can actually be used to solid model the bullet in three dimensions throughout its flight. When we model against the actual flight path, we can see the bullet is not in axial profile with its flight direction. When this occurs, the bullet is presenting to the wind with an inherent amount of yaw, which increases drag and changes the outcome of the BC model. The bullet is spinning in either a right- or left-handed

rotation if there is a wind quarter value on the nose. The direction of the rotational force of the spin causes the nose of the bullet to precess or climb into that wind. You end up with a bullet not traveling along its intended axial path, but presenting to the air ahead of it a non-conformal profile and adding an amount of drag again changing its true BC moment from the published BC. This drag slows the projectile at a higher than anticipated or predicted rate, causing rounds to strike lower than intended.

OVER-STABILIZATION OR YAW

Twist rates traditionally must be established so that there is enough remaining rotational energy to stabilize the bullet at the end of its flight, especially for a long-range cartridge. This means that the bullet is over-stabilized at the start of its travel downrange. You can see this when a quarterback throws a football. Everyone wants a nice, tight spiral, but if he puts too much spin on the ball, it wobbles for the early part of its flight. This wobble is called yaw and it is

a function of too much rotational energy as relates to the linear energy — the movement of the football forward. As the rotational energy degrades, the football regains balance between rotational and linear energy and will fall into a tight spiral.


Sport

A shooter and spotter work as a team, and both roles are equally important.

Air Force Senior Airman Aric Shott, left, uses a spotting scope to assist Air Force Senior Airman Austin Cavenaugh as they train with the M24 Sniper Weapon System on Joint Base Elmendorf-Richardson, Alaska.

As this relates to firearms, designers must over-stabilize the bullet at the beginning of its flight so that it “settles down” over the intended range of use. How this relates to BC is really quite simple. Yaw keeps the bullet constantly shifting off of its intended path when compared to its optimal shape — the center axis of the bullet is not at the center of the intended flight path. Once again, you’re presenting the bullet in it’s less than optimal shaped form against the oncoming air, creating additional drag which modifies — actually degrades —

the BC. One company, CheyTac, patented a bullet with balanced flight. This was unique, and the Doppler radar proved this lack of over stabilization and yaw in its early flight profile. The bullet had an extremely high BC-based on the G7 model and retained an incredible amount of energy downrange when compared to more traditional projectiles like the 50 BMG.

The proof of this was found in the trace produced by the Doppler. The CheyTac balanced flight bullet produced a very clean and smooth line throughout

the duration of its flight with a small dip as it went transonic on the downside, meaning that it did yaw slightly as it went through the sound barrier transiting from supersonic to subsonic. Traditional bullets tracked on the Doppler show a fuzzy or hazy initial trace, until the axial energy and rotational energy fall into alignment producing the clean spiral just like that of the football with too much spin.

Unfortunately, balanced flight has yet to come to the vast majority of hunting bullets and you are saddled with over-

stabilization and yaw at the beginning of these bullets’ flight profiles. If you look back historically at many earlier BC calculations, you may assume that they could even be low based upon the numbers being taken over a distance where the bullet has yet to “settle down.” Until the advent of Doppler radar, we unfortunately did not have a good handle on what ballistic coefficient really was.

BC IN 3D

Throughout the years, the shooting public has generally viewed BC as a linear function relating to drag loss of

velocity in bullet drop over distance. The other fascinating effect is that high BC bullets are less affected by the wind in all three dimensions. This means that a higher BC bullet not only travels through the air more efficiently from point A to point B, but that same level of efficiency allows it to fight crosswind. Therefore, a higher BC bullet in general will buck the wind much better and need less left or right correction downrange. That is important for the target shooter seeking a bullet for hunting in a high wind area, for

the higher BC may allow you a much easier correction.

I’m reminded of a particular training session in Idaho where we were working with the high BC CheyTac bullets and a group of Marines who were training with us shooting 50 BMG sniper rifles. The day became very interesting as the winds came up and they ultimately ran out of the ability to correct for drift based on limitations of their scopes. Conversely, in the same range and conditions, the CheyTac bullet — with its extremely high BC — was only requiring 12

minutes of correction and scoring solid hits.

FACTORS IMPACTING BC

BC can be impacted by a wide range of things like those listed above. But there are some constants that will provide interplay with the published ballistic coefficient. By constants I refer to variables that will always be there. Wind may or may not cause precession based upon its angle and speed, or lack thereof. But two items you encounter every day will always have an impact on your data tables or software — barometric pressure

and slant angle of shot. In the case of barometric pressure, you're impacting the media through which the bullet must fly, thereby modifying the effects of drag and the BC as well. In the case of slant angle, while the distance remains the same, shooting up or down changes the effect of gravity which, while not directly relating to BC, does change the amount of correction necessary to place the bullet on its intended target.

BAROMETRIC PRESSURE

Barometric pressure is the measure of air density through which the bullet must

travel. Air is not air. You want to always reflect upon barometric pressure as actual barometric pressure not corrected sea level pressure. You need to think of air as the medium through which the bullet must transit. Like any medium, changes occur that can affect the bullet’s flight through it. Low barometric pressures like those found at higher altitudes provide far less resistance to a projectile at a given speed. Conversely, higher air and barometric pressures such as at sea level create a denser or thicker medium through which to pass. Think of this in

terms of two glasses, each filled with liquids of different viscosity, the idea being to insert a straw into each glass. I’ve use this demonstration a number of times working with snipers around the world to illustrate the effects of air density or barometric pressure. In the first case, you have iced tea, representing a very low barometric pressure. In the second glass, honey — still liquid, though much, much thicker and therefore resistant to an object passing into and through it. In these demonstrations, the students take two straws and force them

into the glasses. One goes very quickly and easily into the iced tea, while in the other the resistance is obvious and more pressure is needed to pass the straw through the thick honey.

Let’s consider this with the bullet traveling through dense or thin air with a higher barometric pressure like what you find at sea level or when a high pressure front comes through — it’s a lot like the bullet transiting through a medium more consistent with something like honey than iced tea. When hunting or shooting at high elevation where the air becomes

thinner, there is far less resistance on the bullet as it transits through the medium of air. So, in each of these cases, ballistic coefficient is modified by density in terms of its ability to be predictive.

SLANT ANGLE

When shooting up or down hill, the curve of the bullet’s flight path is modified due to slant angle. While this does not truly impact the BC of a bullet, you will see less drop due to the angle. It has the given effect of increasing BC in a practical sense, requiring you to aim

lower than you normally would in a flat-shooting scenario.

A U.S. Army sniper and his spotter watch over members of their unit as they enter a small village near the Pakistan border in Paktika province, Afghanistan.

TARGET REFERENCE POINTS

TRP’s, or Target reference points are a tool of the military sniper and the concept becomes quite applicable to the modern hunter. In a sniping situation, TRPs are developed along paths of ingress or egress where the opposing force may appear. The same concept is applied to the hunter when working from a specific point overlooking a valley from a ridge or in any place where you have determined game may transit. You can establish mobile TRPs and use them in conjunction

with ballistics software as identified locations where you anticipate a shot may take place. You can run your scenarios on each location based upon environmental factors like slant angle and wind speed, building a small cheat sheet or dope sheet for each. That will give you a strong indication of required holdover for that location on a game animal. If you’re working with a spotter, he too should be aware of these and use a numbered system to call the TRP in question when game appears. Through this method, you will have a quicker, more accurate

response time for a shot. Again, this drifts off of the general BC concept but reaches into the realm of practical application in real-world hunting situations.

All of the above are items for you to consider in your practical application of ballistic coefficient to real-world firing solutions and situations. There are a number of great software packages available for use in assisting with predictive solutions for scope correction. One of the best uses of these packages is at the range under varying conditions to determine how your individual projectile

and rifle perform against the predictions as generated. Once this is done, you can build your discrete fudge factor in using the BC and software available. The use of a handheld device and a good software package — especially those based in Doppler radar — will positively impact your hunting situations and rates of success. Technology has come a long way in our field and its benefits can be realized all over the world.

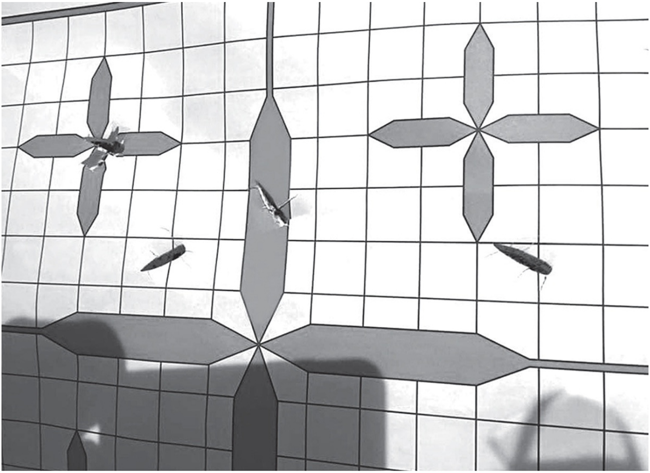
Doppler radar has changed the way in which we think about our bullets and the way they fly. A good ballistic computer

system is not only helpful in the field but makes a great resource when sitting at home to run scenarios and truly learn what your rifle and projectile combination are capable of under a wide variety of circumstances.

CHAPTER 10
BULLET STABILITY AND SPIN DRIFT

The concept of spinning a bullet to keep it stable goes back to the days of muzzleloading rifles, when the English, armed with smoothbore Brown Bess muskets, saw the advantages of the Pennsylvania and Kentucky rifles. While the Brown Bess was not what you'd

describe as an accurate firearm, lacking any rifling at all, the Continental rifles were extremely accurate for their time, and gave the Revolutionaries a definite advantage.



Unstable bullets can and will hit the target sideways, as clearly shown here.


22 CAL .224 DIA
69 GR. HPBT-MATCH
1380

The 69-grain Sierra MatchKings are off-limits in this .22-250 due to a slow twist rate that won’t stabilize them.

The spinning motion of a projectile keeps it stable in flight; but exactly how much spin is required for each projectile? This is important information for those who want to utilize the long, sleek bullets that give such good trajectory and wind deflection performance. Invariably, the modern bullet trend has gone longer and heavier within each caliber, but the barrels of rifles produced over the last century can only spin a bullet so fast. If

you try to exceed the capability of the barrel’s twist rate, your bullet will lose gyroscopic stability, and you’ll see your accuracy fall apart. Your bullets will hit the target sideways, creating what is known as a keyhole.

Certainly, the ballistic engineers of yesteryear couldn’t have envisioned this trend, and the barrel you own will dictate the bullets you can use. As I’ve related elsewhere in this book, I own a couple of rifles that are handicapped, if you will, by the twist rate of their barrels. My .22-250 Remington comes quickly to mind, and

though I would love nothing more than to use 69- and 77-grain Sierra MatchKing bullets in this rifle, my 1:14-inch twist rate simply won’t stabilize them.

First, the twist rate of your firearm must be known, and I’ve described that process in the interior ballistics section, under chapter 5. You can use some mathematics to determine exactly how heavy a bullet a given barrel will stabilize. The Miller Twist Rule, developed by Don Miller, uses the following factors for determining the proper stabilization rate for a bullet.

You’ll need to know the mass (m) of the bullet in grains and that’s easy enough. You’ll need the bullet’s diameter in inches (d). And the bullet’s length in calibers (l), plus the twist rate of your barrel in calibers (t). The equation works like this:

The 53-grain bullet is a much better choice for the 1:12 twist rate.

$$\mathbf{s = 30m/(t^2\ d3\ l\ (1+l^2))}$$

The s figure that you’re solving for is the gyroscopic stability factor, which will indicate just how stable the bullet will be during flight. Any bullet that ends up with an s factor greater than 1.5 (this number has no units) will be stable, while a figure ranging between 1.0 and 1.5 is considered to have marginal stability. If the figure is less than 1.0, the bullet will be unstable. Some examples:

A 180-grain Swift Scirocco II, with a G1 BC of 0.520, and a length of 1.435 inches, fired from my .300 Winchester Magnum with a 1:10 twist rate.

Converting the bullet length to calibers (1.435/.308) yields a figure of 4.659. Converting the 1:10-inch twist rate into calibers (10/0.308) gives you 32.468. Plugging these values into Miller's equation results in an s factor of 1.67; indicating that this bullet will have good stability when fired from this barrel.

Supposing I wanted to use the 62-grain Swift Scirocco II in my .22-250 Remington, with a 1:12 twist rate, the bullet having a length of 0.928 inches. I'd first check the stability factor in this rifle. Multiplying the weight of the bullet in

grains by the constant factor of 30 (which Miller derived to give an approximation of velocity, and happens to work rather well) gives you 1,860 on the top of the equation. Convert the bullet length into caliber and you get 4.143, while the twist rate converted into calibers per turn (t) is 53.571. Calculate the squares, cubes, multiplication and division, and you'll end up with an s value of 0.72; far below the desired minimum of 1.00. Were I to load this bullet in my rifle, I'd see lousy accuracy. The bullet would hit the target

sideways, as it begins to yaw coming out of stable flight.

The 130-grain Cutting Edge Match Tactical Hunting, or MTH bullet worked out much better than a 140-grainer would have in the author’s gun, which has a 1:8 twist rate barrel.

Let’s now check the bullet that has worked in my rifle for so long — the Sierra 53-grain flat-base MatchKing. This bullet measures 0.694 inches, considerably shorter than the 62-grain Scirocco, though it’s only 9 grains lighter due to the flat base and lack of polymer tip. Crunching the numbers in the Miller formula, I obtain an s factor of 1.41, indicating that I’ve got good stability. This has been proven for years, as I’ve used this load for varmints and predators out to 400 yards and beyond.

These results can be enlightening. Certain cartridges can be blessed or cursed by the twist rate of the barrel and other factors like case capacity. This has long been an issue (which I could not understand as a younger man) with the .270 calibers. Why would the .284-inch (7mm) cartridges be able to handle bullets up to 175 grains, yet drop the bore diameter down by just 0.007 inches, and bullet weights top out at 150 grains. It just didn’t make a lick of sense. Well, based on Miller’s equation, the answer is simple. The barrels of almost all the .270

cartridges use a 1:10 twist rate, and that twist simply won’t stabilize a bullet heavier than 150 grains. Change the twist rate to 1:8 and you could use bullets as heavy as 170 grains, and that would certainly be a nice prospect for larger game, or for a high BC choice for long-range work. Berger makes the Extreme Outer Limits Elite Hunter in .277 at 170 grains, which won’t work in the conventional barrels, but if you were to order a custom .270, I’d recommend the faster-than-normal twist rate so you can take advantage of the design. That’s true

as well of the older Barnes original round-nose at 170 grains. I guess this issue with the .270 might explain why they make a good hunting cartridge, but haven’t been used very often as a true long-range target rifle.

Utilizing the bullet’s length in the Miller Twist Rule is an important factor. It can make the difference in choosing a bullet that may seem like it will work, yet will actually be unstable — and one that truly is a tack-driver. My 6.5-284 Norma with its 1:8 twist barrel will easily handle a conventional cup and core bullet

weighing as much as 160-grains. The 156-grain Norma Oryx and 160-grain Hornady InterLock have given good accuracy in this rifle, as well as excellent terminal performance. The 140-grain bullets work equally well, and within this group the 140-grain North Fork hollowpoints have ruined more than one deer’s day, while the Hornady ELD-Match bullet has given the best accuracy of all from this gun. My previous experiences with Cutting Edge Bullets sparked a desire to try their 140-grain MTH (Match Tactical Hunting) bullet. I

simply figured that a 140-grain lead-free bullet would pose no issue, but while discussing this choice with the folks at Cutting Edge, they informed me that I’d need a 1:7.5 twist rate at a minimum and that this bullet wouldn’t stabilize in my rifle. Well, that didn’t make a heck of a lot of sense, until I ran the numbers (why I doubted them in the first place is beyond me) and I came up with a stability factor of just about 1.27. This would be barely marginal, and certainly not a good choice in my rifle for long-range shooting. I opted for the 130-grain

MTH bullet, and I’m very happy with the results.

You see, the lead-free construction of the Cutting Edge MTH is the culprit here, and it’s not necessarily a bad thing. Copper is less dense than lead, so the 140-grain MTH is 1.505 inches long, as compared to the 140-grain ELD-Match at 1.380 inches. But the center of gravity is much farther rearward in the Cutting Edge than in the Hornady. Based on the difference in length and center of gravity, the Hornady bullet gives me a stability

factor of 1.63, which is much better suited to my purposes.

There is a fantastic tool available on the Berger website, a twist rate calculator (http://www.bergerbullets.com/twist-rate-calculator). It allows you to enter the pertinent data relating to your bullet/rifle combination, and delivers not only the stabilization factor — which they refer to as “SG” — but indicates whether or not your BC is optimized for your bullet. This website is a gem, and worthy of a bookmark on your favorites bar. It does note that the Miller Twist Rule may come

up inaccurate for flat-based bullets as the rule bases its mathematics on a projectile profile shaped like a football, and offers some suggestions for calculations regarding flat-based bullets.

OVER-STABILIZATION

How does a faster twist rate affect standard bullets? I’ve read the theories that purport that spinning a bullet too fast will have a dramatic effect on the velocity — that the energy is eaten up by the revolutions of the bullet. However, I have found no evidence to prove this point while doing testing and research for

this book, and all scientific data points to the fact that any reduction in velocity caused by bullet spin is so minimal as to be disregarded.

However, I have seen a barrel with a fast twist rate take a light-for-caliber bullet — these were of a highly frangible varmint design — and spin the jacket out from around the lead core. Come to think of it, I’ve actually seen this in a couple of calibers, namely a .223 Remington and .264 Winchester Magnum, and in both instances the bullets were on the light side of the spectrum. That .264 Magnum

was launching 85-grain hollowpoints and, if I recall correctly, they were Sierra Varminter bullets that wouldn’t hit the 100-yard target at all. On the third shot, I saw bark fly about 15 yards down our backyard range, five or six yards to the right. While the Sierra Varminter certainly delivers near-explosive results on woodchucks and prairie dogs (and has proven to be an accurate bullet over the years), this combination of high velocity and a twist rate on the faster side ended up being just too much for the little 85-grain pill. I wish I still had the rifle to

observe the twist rate, but I’d bet it was in the neighborhood of 1:8. That rifle had no issues with the 129- and 140-grain bullets. On the other hand, 85-grain bullets didn’t work out so well after all.

Over-stabilization can cause things to come apart, and that’s never a good thing.

The bottom line to all of this? I’d much rather have a bullet over-stabilized than under-stabilized, especially for long-

range shooting. However, as valuable as a fast rate of twist is to stabilizing a longer projectile, it will magnify any flaws in the construction of the bullet. Should you have a small void in the lead core, or a jacket that is not perfectly concentric, a faster twist rate will surely bring this out, and I firmly believe that the inexplicable ‘flier’ — that one shot that ruins your group size when you feel certain that you’d held perfectly — can sometimes be attributed to a slight deformation in bullet construction. (I’m currently working on the manuscript for my next book:

Massaro's Book of Believable Shooting Excuses. It's sure to be a winner.)

SPIN DRIFT

The very act of spinning a bullet results in a downrange phenomenon known as spin drift. At longer distances the spin that keeps the bullet in a nose-forward flight pattern will cause it to drift in the direction in which it is spinning. Put simply, if you have a right-hand twist in your barrel, your bullets will drift right, the opposite for a left-hand twist. How much the bullet will drift is based upon the stability factor of the bullet, and

the time of flight. While left-hand twist barrels are a rarity these days, most of our rifles will spin toward the right. Where wind is a variable, and our ability to judge it is limited, spin drift is a predictable effect. Bryan Litz, in his excellent book, *Applied Ballistics for Long Range Shooting*, has derived the equation for computing the predicted spin drift, and he puts it like this:

$$\mathbf{Drift = 1.25(SG + 1.2)tof^{1.83}}$$

In this equation, drift is measured in inches, SG is what Litz refers to as the

stabilization factor as determined by the Miller Twist Rule, and *tof* is the time of flight in seconds. It isn’t difficult to find information regarding time of flight in a good reloading manual, or on a component bullet company’s website, and we’ve already derived the stability factor, so the equation isn’t very difficult to solve. Personally, when the shots get long enough that I need to take spin drift into consideration, I consult my Kestrel Anemometer to arrive at the adjustment. While it sounds like a cop-out and a dependence on technology, I will say that

with all the other factors involved in long-range shooting it’s difficult to keep another chart in my head. The Kestrel has made the art of long-distance shooting much more manageable.

In a hunting situation (unless you fully intend to pursue unwounded game at ranges over 500 yards, something I personally won’t do and would advise against) the spin drift values are negligible, and can almost be taken out of the equation. For a shot at the outer limits of my hunting ranges (keeping in mind that all of my rifles are outfitted with

right-hand twist barrels) I will reduce the amount of wind hold in a right-to-left wind — as the wind deflection is fighting the spin drift — and give a bit more hold at longer distances in a left-to-right wind, as the wind will work in conjunction with the spin drift effect. On the other hand, if you fully intend to play the long-range game, you'll want the best tools available, and a handheld ballistic computer ranks right up there as one of the best, so long as you have a working knowledge of what effects are happening.

I plugged my 6.5-284 Norma parameters into the Hornady 4 Degrees of Freedom ballistic calculator, and got the following dope chart for my gun:

Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	ComeUp (MOA)	Wind Drift (in.)	Wind Drift (MOA)	Spin Drift (in.)	Spin Drift (MOA)	TOF (sec.)
0	2580	2070	-1.75	0	0	0	0	0	0
25	2,545	2,015	-0.2893	-1.1052	0.0348	0.1329	-0.0027	-0.0102	0.0293
50	2,511	1,961	0.8337	1.5923	0.1396	0.2666	-0.0108	-0.0206	0.0589
75	2,477	1,908	1.6128	2.0536	0.3158	0.4021	-0.0246	-0.0313	0.089
100	2,443	1,857	2.0384	1.9467	0.5649	0.5395	-0.0441	-0.0421	0.1195
125	2,410	1,806	2.1003	1.6046	0.8886	0.6789	-0.0696	-0.0532	0.1504
150	2,376	1,756	1.7875	1.1381	1.2887	0.8205	-0.1013	-0.0645	0.1817
175	2,343	1,707	1.0913	0.5955	1.7665	0.964	-0.1392	-0.076	0.2135
200	2,310	1,660	0	0	2.3239	1.1097	-0.1837	-0.0877	0.2458
225	2,277	1,613	-1.4988	-0.6362	2.9628	1.2575	-0.2347	-0.0996	0.2785
250	2,245	1,567	-3.4157	-1.3048	3.6849	1.4076	-0.2927	-0.1118	0.3116
275	2,212	1,522	-5.7625	-2.0012	4.4918	1.5599	-0.3577	-0.1242	0.3453
300	2,180	1,478	-8.5537	-2.7229	5.386	1.7145	-0.4299	-0.1369	0.3794
325	2,148	1,435	-11.8016	-3.4678	6.3697	1.8717	-0.5097	-0.1498	0.4141
350	2,116	1,392	-15.5195	-4.2346	7.445	2.0314	-0.5971	-0.1629	0.4493
375	2,084	1,351	-19.7216	-5.0224	8.6144	2.1938	-0.6924	-0.1763	0.485
400	2,052	1,310	-24.4248	-5.8314	9.8806	2.359	-0.7958	-0.19	0.5213
425	2,021	1,270	-29.6425	-6.6609	11.2458	2.527	-0.9076	-0.2039	0.5581
450	1,990	1,231	-35.3907	-7.5107	12.7126	2.6979	-1.0279	-0.2181	0.5955
475	1,958	1,193	-41.6884	-8.3816	14.284	2.8718	-1.1572	-0.2327	0.6335
500	1,927	1,155	-48.5516	-9.2734	15.9625	3.0488	-1.2956	-0.2475	0.6721
525	1,896	1,118	-55.9986	-10.1864	17.7517	3.2291	-1.4434	-0.2626	0.7113
550	1,865	1,081	-64.0494	-11.1213	19.6555	3.4129	-1.6008	-0.278	0.7512
575	1,834	1,046	-72.7245	-12.0786	21.678	3.6004	-1.7681	-0.2937	0.7918
600	1,802	1,010	-82.0449	-13.0589	23.8232	3.7919	-1.9455	-0.3097	0.833
625	1,771	975	-92.0322	-14.0626	26.0954	3.9874	-2.1333	-0.326	0.875
650	1,740	941	-102.714	-15.0911	28.4996	4.1873	-2.3319	-0.3426	0.9177
675	1,709	908	-114.111	-16.1446	31.0398	4.3916	-2.5414	-0.3596	0.9612
700	1,677	875	-126.251	-17.2243	33.721	4.6005	-2.7623	-0.3769	1.0055
750	1,615	811	-152.875	-19.4662	39.5271	5.0331	-3.2397	-0.4125	1.0967
800	1,553	750	-182.827	-21.8251	45.9626	5.4868	-3.7665	-0.4496	1.1914
850	1,491	692	-216.378	-24.3109	53.0767	5.9633	-4.346	-0.4883	1.2899
900	1,430	636	-253.835	-26.9349	60.9246	6.4648	-4.9817	-0.528	1.3926
950	1,368	582	-295.537	-29.7096	69.5677	6.9934	-5.678	-0.5708	1.4999
1000	1,308	532	-341.879	-32.6499	79.0749	7.5516	-6.4399	-0.615	1.612
1050	1,247	484	-393.297	-35.7719	89.5193	8.142	-7.2726	-0.6615	1.7295
1100	1,188	439	-450.297	-39.0948	100.9817	8.767	-8.1808	-0.7102	1.8527
1150	1,130	397	-513.448	-42.6396	113.5444	9.4291	-9.1681	-0.7614	1.9822
1200	1,080	363	-583.389	-46.4295	127.2461	10.1266	-10.2348	-0.8145	2.1182
1250	1,044	339	-660.752	-50.4833	141.9153	10.8423	-11.3854	-0.8698	2.2597
1300	1,017	321	-746.064	-54.8094	157.3492	11.5591	-12.627	-0.9276	2.4055
1350	997	309	-839.755	-59.4078	173.3752	12.2646	-13.9678	-0.9881	2.5546
1400	981	299	-942.16	-64.2726	189.8739	12.9521	-15.415	-1.0515	2.7065
1450	967	291	-1053.57	-69.395	206.7869	13.6193	-16.9737	-1.1179	2.8606
1500	953	283	-1174.25	-74.7665	224.0946	14.2673	-18.6482	-1.1873	3.017

View a text version of this table

The Hornady ELD Match bullet.

I have underlined the 500-yard mark, as that is where most hunters would draw the line in the hunting fields, and you can see in column for spin drift that the 500-

yard value is 1.30 inches (as rounded up). I’m not a bad shot, yet I’m no sniper, but for me to honestly say that I can hold within an inch-and-a-quarter at 500 yards would be severely stretching the truth. Spin drift is a factor in exterior ballistics, but it is a small factor in the hunting world in comparison to the effects of gravity and wind deflection.

Take it out past 700 yards, and you’ll see where the spin drift can become an issue. Again, from the Hornady calculator shown above.

At exactly 1,000 yards the simple act of spinning the 140-grain Hornady ELD-Match causes a drift (to the right due to the right-hand twist of the barrel) of almost 6-½ inches; more than enough to push it off the edge of 12-inch plate if not accounted for. At 1,500 yards, you’ll be off the right side of a 36-inch plate. In order to put your bullet where you want to at long range, you need to figure in this phenomenon.


ELD™ MATCH
Extremely Low Drag
• Heat Shield™ tip forms the perfect meplat.
• No tip deformation from aerodynamic heating.
• Extremely low drag bullet profile delivers the highest in class BCs.
• Swaged lead core provides uniformity and balance.
• AMP® jacket design for optimum concentricity and accuracy.
FEATURING
AMP
BULLET JACKET

CHAPTER 11
DENSITY ALTITUDE

While many effects on a bullet in flight are predictable — leaving the ever-changing wind as a definite variable — the atmosphere itself can and will change, to further affect its flight path. If you take a look at most of the ballistic calculators, they use a baseline temperature of 59°F, and a barometric pressure of 29.92 inches of mercury, at mean sea level. This

apparently random set of data is based on the International Civilian Aviation Organization’s ‘Standard Atmosphere,’ and can be adjusted from there. The ICAO figures do not account for the humidity levels of the atmosphere, but reflect the changes in both temperature and pressure, with respect to elevation. Let’s look at one set of data for a .300 Winchester Magnum, using a Hornady 178-grain ELD-X at 2,960 fps, at the ICAO baseline atmosphere:

Marine Corps Lance Cpl. Eleanor H. Roper, front, pulls a weather infantry kit up a slope during a field exercise on Marine Corps Mountain Warfare Training Center in Bridgeport, Calif.

A Marine fires at the enemy allowing other Marines to maneuver during an assault on an enemy position during the final six days of Mountain Exercise at Bridgeport, Calif.

Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	ComeUp (MOA)	Wind Drift (in.)	Wind Drift (MOA)	Spin Drift (in.)	Spin Drift (MOA)	TOF (sec.)
0	2,960	3,464	-1.75	0	0	0	0	0	0
50	2,876	3,270	-0.3503	-0.6691	0.1297	0.2477	-0.0098	-0.0188	0.0514
100	2,793	3,084	0	0	0.5259	0.5022	-0.0403	-0.0385	0.1043
150	2,711	2,905	-0.7638	-0.4863	1.2016	0.765	-0.0929	-0.0591	0.1589
200	2,629	2,733	-2.7082	-1.2932	2.1709	1.0366	-0.1693	-0.0809	0.215
250	2,549	2,568	-5.9106	-2.2579	3.4502	1.318	-0.2714	-0.1037	0.273
300	2,469	2,410	-10.4487	-3.3262	5.055	1.6092	-0.4011	-0.1277	0.3328
350	2,390	2,259	-16.4104	-4.4777	7.003	1.9108	-0.5604	-0.1529	0.3945
400	2,312	2,114	-23.8933	-5.7045	9.3132	2.2235	-0.7514	-0.1794	0.4583
450	2,236	1,976	-32.9989	-7.0031	12.0046	2.5476	-0.9763	-0.2072	0.5243
500	2,160	1,845	-43.8426	-8.3739	15.0983	2.8838	-1.2375	-0.2364	0.5925

View a text version of this table

Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	ComeUp (MOA)	Wind Drift (in.)	Wind Drift (MOA)	Spin Drift (in.)	Spin Drift (MOA)	TOF (sec.)
0	2,960	3,464	-1.75	0	0	0	0	0	0
50	2,888	3,297	-0.3496	-0.6678	0.111	0.212	-0.0098	-0.0186	0.0513
100	2,816	3,136	0	0	0.4491	0.4289	-0.0398	-0.038	0.1039
150	2,746	2,980	-0.7422	-0.4725	1.024	0.652	-0.0914	-0.0582	0.1578
200	2,675	2,829	-2.6328	-1.2572	1.8462	0.8816	-0.166	-0.0792	0.2132
250	2,605	2,684	-5.7344	-2.1905	2.9266	1.118	-0.2649	-0.1012	0.27
300	2,536	2,543	-10.1191	-3.2213	4.2773	1.3616	-0.3899	-0.1241	0.3284
350	2,468	2,408	-15.8535	-4.3257	5.91	1.6126	-0.5425	-0.148	0.3883
400	2,400	2,278	-23.0117	-5.4941	7.8375	1.8712	-0.7243	-0.1729	0.4499
450	2,333	2,153	-31.6777	-6.7227	10.074	2.1379	-0.9371	-0.1989	0.5133
500	2,267	2,032	-41.9414	-8.0108	12.6328	2.4129	-1.1827	-0.2259	0.5785

View a text version of this table

Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	ComeUp (MOA)	Wind Drift (in.)	Wind Drift (MOA)	Spin Drift (in.)	Spin Drift (MOA)	TOF (sec.)
0	2,960	3,464	-1.75	0	0	0	0	0	0
50	2,897	3,318	-0.4063	-0.7759	0.0966	0.1845	-0.0099	-0.0188	0.0512
100	2,835	3,176	0	0	0.3904	0.3729	-0.0401	-0.0383	0.1036
150	2,773	3,039	-0.6719	-0.4278	0.8885	0.5656	-0.0918	-0.0585	0.1571
200	2,711	2,907	-2.5	-1.1938	1.5978	0.7629	-0.1663	-0.0794	0.2118
250	2,651	2,778	-5.5156	-2.107	2.5261	0.965	-0.2649	-0.1012	0.2677
300	2,590	2,653	-9.7656	-3.1087	3.6818	1.172	-0.3888	-0.1238	0.325
350	2,530	2,531	-15.2891	-4.1717	5.0746	1.3847	-0.5395	-0.1472	0.3836
400	2,471	2,414	-22.1953	-5.2991	6.7135	1.6028	-0.7186	-0.1716	0.4436
450	2,412	2,300	-30.5156	-6.4761	8.6081	1.8268	-0.9277	-0.1969	0.505
500	2,354	2,190	-40.3281	-7.7027	10.7696	2.057	-1.1685	-0.2232	0.5679

View a text version of this table

Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	ComeUp (MOA)	Wind Drift (in.)	Wind Drift (MOA)	Spin Drift (in.)	Spin Drift (MOA)	TOF (sec.)
0	2,960	3,464	-1.75	0	0	0	0	0	0
50	2,880	3,280	-0.3519	-0.6721	0.1225	0.234	-0.0099	-0.0189	0.0514
100	2,802	3,104	0	0	0.4963	0.474	-0.0404	-0.0386	0.1042
150	2,724	2,934	-0.7549	-0.4806	1.1331	0.7214	-0.093	-0.0592	0.1585
200	2,647	2,771	-2.679	-1.2792	2.0445	0.9762	-0.1693	-0.0808	0.2143
250	2,571	2,613	-5.8431	-2.2321	3.2446	1.2395	-0.271	-0.1035	0.2718
300	2,496	2,462	-10.3199	-3.2852	4.7478	1.5114	-0.3999	-0.1273	0.331
350	2,421	2,317	-16.1917	-4.418	6.5696	1.7926	-0.5581	-0.1523	0.3921
400	2,347	2,178	-23.5435	-5.621	8.7259	2.0833	-0.7475	-0.1785	0.455
450	2,274	2,044	-32.4729	-6.8915	11.2346	2.3842	-0.9702	-0.2059	0.5199
500	2,202	1,917	-43.0823	-8.2287	14.1138	2.6957	-1.2286	-0.2347	0.5869

View a text version of this table

Now let’s change the data to mimic a Texas whitetail deer hunt, at 2,000 feet above sea level, at 80°F, at 26.50 Hg, assuming the same muzzle velocity:

Next, let’s take our rifle to Montana, for a bighorn sheep hunt (since we’re pretending, I can actually afford this hunt!) at 9,000 feet above sea level, at 32°F, with a pressure of 21.50 Hg:

Lastly, let’s take our rifle to the Alaskan coast (let’s say for a brown bear, while we’re dreaming), where the elevation is at mean sea level, pressure is 27.50 Hg, and temperature is 40°F.

If you examine the way that bullet, at the same muzzle velocity, performs in different environments, you’ll see that there is definitely a trajectory shift, especially approaching 400 and 500 yards. The change is a result of the density of the atmosphere, due to the combined effects of elevation and temperature.

There’s a simple rule: when the elevation is up, bullet trajectory is up. If the temperature is up, the bullet’s trajectory is up. The reverse applies as well. If you’re traveling to a new hunting destination, ask the outfitter for the data (elevation, average temperature, etc.) and prepare a new dope card for your hunt. A Kestrel Elite weather station/ballistic computer will also capture the environment of your new hunting location, and adjust your trajectory curve accordingly.

HUMID AIR VS. DRY AIR

The one aspect of the atmosphere that ICAO neglects to take into account is the humidity of the atmosphere, which needs to be considered for trajectory purposes. The atmosphere is comprised of roughly 78% Nitrogen and 20% Oxygen, with some Carbon Dioxide and minimal amounts of other trace gas thrown into the mix. What I'm about to tell you will defy common sense, but it is true. When the air gets humid — you know those summer days when you're stuck to your clothes and just can't seem to cool off — the air is actually thinner than it is on

those nice, dry days. It took me a while to wrap my head around it, as it defied logic, but the water vapor in the air on a humid day is lighter than Nitrogen, thus the air is lighter and thinner when it is saturated with water vapor.

As we saw with the trajectory charts above, thinner air at a higher elevation is

easier for the bullet to fly through, resulting in a flatter trajectory. The humidity of the air has the same effect. If the air at a given location is humid, the resulting trajectory will be a bit flatter than if the air was dry.

The effect isn’t huge, until you get out past the 500-yard mark, and any good ballistic calculator will reveal the difference with your chosen load.

U.S. Army Sgt. Andrew Barnett scans the area using the optic lens on his M14 enhanced battle rifle

CHAPTER 12
WIND DEFLECTION

If there is one factor that is the most difficult to deal with when it comes to a long-range shot, it is the wind. Gravity is a predictable effect. Spin drift and the other, less dramatic effects don’t really come into play until the distances get out past 700 or 800 yards. Wind, however, is an ever-changing problem, and its effects aren’t always taken at face value. It’s one

of those things that you can’t see, only its effects. If you intend to become any sort of long-range shooter, you’re going to need to get a pretty good handle on calling the wind and adjusting for it.

The term ‘wind drift’ is often used, though ‘wind deflection’ is the proper terminology, though frankly I don’t care which you use, so long as you understand it, and I’ll use both here. The effects of crosswind drift are dependent on the velocity of the wind, the velocity of the bullet, and the bullet’s ballistic coefficient. That effect is predictable to a

certain degree if you know for certain what the wind speed and direction are all the way from muzzle to target. Truthfully, knowing all the wind characteristics along the bullet’s flight path is highly improbable on a target range, and nothing short of impossible in a hunting situation, unless you can verify that there is no wind whatsoever. But there are tools and methods you can use to help defeat the wind’s effects, and properly place the bullet on target. Learning to call the wind is equal parts science and art; you’ll need to spend some time in the field doing

nothing more than watching, and if you can get the opportunity to sit next to an experienced wind caller, definitely take advantage of that. I had the privilege of spending eight days at the FTW Ranch outside of Barksdale, Texas, with none other than Douglas “Dog” Pritchard, and I learned a ton from that man. My time was spent equally divided as the shooter and the spotter, engaging targets from 200 out to 1,800 yards into and across the broken Texas canyons, all the while discussing the wind calls with Pritchard. While I cannot garner the wisdom and

experience of his Navy Seal training in eight days, I do know I’m much better at calling wind than I ever imagined I could be. I’ll say this several times throughout this book: if you’re serious about long-range shooting or hunting, the SAAM course at the FTW Ranch is a worthy investment.

There is a definite difference between shooting long-range steel or paper targets, and long-range hunting. If ever I could make a case for the most precise wind calls possible, it is in the hunting fields. Should you miss the steel plate at

800 yards due to an incorrect wind call, the only thing that gets hurt are your feelings. Make that same mistake on an elk, moose or other game, and you could end up with a wounded, unrecoverable animal. Long-range hunting is in vogue right now, promulgated by several television shows that make it seem easy to hit an animal out to 700 yards, and I feel this is simply wrong-headed. I don’t put down anyone’s method of hunting, so long as it’s legal and ethical, but there are so many unseen wind variables at those distances that a wind call that is off by a

mere 2 mph can cause havoc, even if the shooter is disciplined and well-practiced.

That said, there are certain hunts that will call for a shot much longer than the average. Mountain goat, Dall sheep, and certainly Marco Polo argali fall into this category, as can pronghorn antelope. There are times where you just cannot get closer, and you’ll need to be prepared for a distant shot. In addition to knowing the trajectory of your chosen cartridge, you will definitely need to know how to dope the wind. All the high BC bullets and baby bottle-sized cartridges won’t

combat a misread wind call, so you need all the advantages you can get to make it happen. I'm generally not a huge electronic gizmo guy, but the tools available to the long-range shooter — particularly those used to measure the wind — are not only extremely helpful but I've found them to be an integral part of my gear, just like my riflescope or choice of bullets. I rely on a Kestrel Elite, which has not only the weather station features but also comes with the Applied Ballistics computer, to wrap things up into one convenient hand-held package.

As with any electronic device, batteries can die at the most inopportune time, and capacitors can suffer from the "ghost-in-the-machine" syndrome, so I make a backup chart that I carry with me. Sometimes a hard copy is invaluable, even if you have to make adjustments on the fly. Let's first look at how wind drift works, then how to use visual clues in the field to get as close to the true wind call as possible.

BASIC WIND EFFECTS

Any projectile, be it a ping-pong ball, arrow or high-speed bullet, will be

affected in some manner by crosswind, even if the amount of deviation is minute. For our purposes there is an accepted margin of error within which we may still hit the target. In order to best understand how wind drift affects a bullet in flight, we’ll pick a constant wind speed — let’s use 10 mph for convenience — and a particular bullet at a known speed. Just because I love the rifle/cartridge combination, let’s use a .300 Winchester Magnum, driving a 180-grain Swift Scirocco II at a muzzle velocity of 2,960 fps (my own personal rig). For

demonstrative purposes, the wind will be left to right, at the full 10 mph value. Let’s look at the chart, and observe the wind drift at every 50 yards out to 500 yards, a reasonably sane limit for any hunting shot.

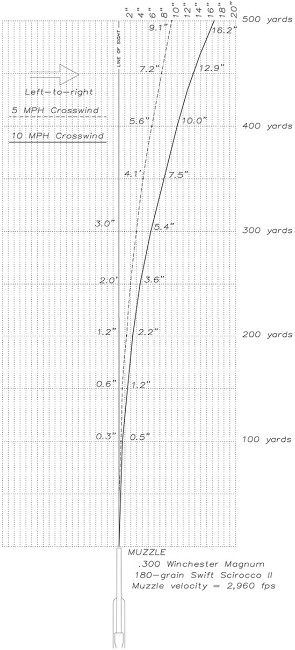
While some of this may be obvious to an experienced shooter who’s spent time out past 300 yards, it may be demonstrative to those hunters who spend most of their time inside 200 yards, as I do more often than not in the deer woods. If you’re headed out West for an elk, antelope or prairie dog hunt, this will

give you an idea of the mayhem that crosswinds can create. This rifle is considered to be among the most flat-shooting setups, and the Swift Scirocco II, with a G1 BC of 0.520, has no flies on it as a hunting bullet, yet you can easily see that at only 300 yards a wind deflection of 5.4 inches may be enough to push your shot out of the vital area. Take things out to 400 yards, and you'll see the drift jumps out to an even 10.0 inches, which is definitely trouble. I think you're getting the idea as to how important the wind is when it comes to hunting at

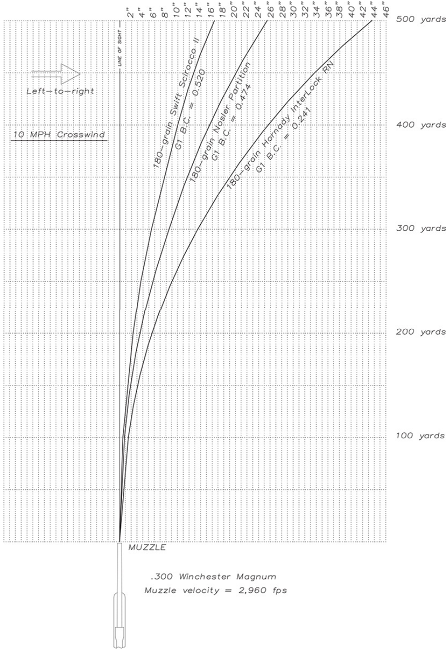
longer ranges. At 500 yards, I’ve got just over 16 inches of wind drift, which will make for some serious contemplation, especially when you compound that figure with the 34 inches of drop — and that’s using a hunting zero of 250 yards. There’s an awful lot of thinking that goes into a shot at this distance, and then you’ve probably got a less-than-ideal shooting position from which to work, as well as the heart-pounding excitement generated by the chance at bagging your trophy.

Now, you are dealing with a known wind and a known distance. Most hunters think about distance in terms of trajectory, concentrating on the gravitational effect, but this little wind chart clearly demonstrates that you need to start thinking in two dimensions, with the horizontal dimension being much more difficult to deal with than the vertical. Reduce the muzzle velocity, as with a .308 Winchester or .30-06 Springfield, and you’ll see an increased wind drift. Same fact applies with a bullet that has a lower ballistic coefficient;

which is why the choice of cartridge and bullet play a very important role in the long-range game. Here’s the rub: Let’s lower the BC in my .300 Winchester by switching to a 180-grain Nosler Partition — a bullet that has a fantastic reputation in the game fields — and compare the wind drift numbers above. Even though the Partition is a spitzer bullet, its flat base reduces the G1 BC to 0.361, and thereby gives the wind the advantage.



2"
4"
6"
8"
10"
12"
14"
16"
18"
20"
LINE OF SIGHT
500 yards
400 yards
300 yards
200 yards
100 yards
Left-to-right
5 MPH Crosswind
10 MPH Crosswind
9.1"
16.2"
7.2"
12.9"
5.6"
10.0"
4.1"
7.5"
3.0"
5.4"
2.0"
3.6"
1.2"
2.2"
0.6"
1.2"
0.3"
0.5"
MUZZLE
.300 Winchester Magnum
180-grain Swift Scirocco II
Muzzle velocity = 2,960 fps



2"
4"
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12"
14"
16"
18"
20"
22"
24"
26"
28"
30"
32"
34"
36"
38"
40"
42"
44"
46"
LINE OF SIGHT
500 yards
400 yards
300 yards
200 yards
100 yards
Left-to-right
10 MPH Crosswind
180-grain Swift Scirocco II
G1 B.C. = 0.520
180-grain Nosler Partition
G1 B.C. = 0.474
180-grain Hornady InterLock RN
G1 B.C. = 0.241
MUZZLE
.300 Winchester Magnum
Muzzle velocity = 2,960 fps

The lower BC figure, when compared to the Swift Scirocco II, requires about a 50 percent increase in wind hold to hit the target, as well as increased drop at longer ranges. At 400 yards, the Scirocco deflects 10 inches, while the Partition moves 15.4 inches; this is an appreciable difference. Change things even further by using a good, old-fashioned Hornady 180-grain round-nose InterLock with a G1 BC of 0.241 and you’ll see horrific wind values. The round-nose moves 13.3 inches at 300 paces, and 25.6 inches at 400 yards! Compared to the Scirocco,

that’s 2.5 times the wind deflection, which makes things much more difficult. While the ballistics aren’t radically affected within 200 yards where I most often use this style of bullet, anything much past that distance and you’ll be doing some math. Should I even remotely think of shooting out to 250 or 300 yards, I’d opt for a different choice of bullet. Funny how important that wind factor can be, especially when combined with bullet drop factor. And while these charts seemingly point to using a bullet with a high BC value all the time, there are

factors in the terminal phase which will come into play that may influence the decision.

So, assuming you've chosen the high BC Scirocco in the .300 Winchester Magnum, you should take a look at wind values that are not the 10 mph baseline. Reducing the wind speed down to 5 mph, the wind drift is cut just about perfectly in half. So, your 500-yard shot now requires a hold of 9 inches into the wind rather than 16 inches — a significant difference.

Inside 300 yards, the 5 mph wind becomes much less influential, especially if you’re talking about game animals and their vital zones. But, for the hunting shots on the longer end of the spectrum, even a 5 mph wind requires a compensatory hold. Another derivation of the chart is the fact that the wind drift for the 500-yard shot is highly dependent upon knowing the wind speed, because you’ve got a 7-inch difference between those two wind values. Should that wind be less than full value, you’ll need to adjust the hold even farther. Let’s look at

how wind that isn’t perpendicular to your shot will influence deflection.

If a wind is blowing directly at your face, or directly at your back, it will have no horizontal effect on your shot. You can simply negate the effect of wind deflection altogether. If the wind is perpendicular to your shot, the full-effect values that I showed in the previous charts can be used as demonstrated. But, if the wind is coming at a different angle, you must reduce the values by the cosine of the angle, in order to arrive at the correct dope. Looking at your situation as

if it were a clock face, you can better estimate the value of the wind, with reference to your baseline, where the winds are perpendicular to the line of flight. Again, assuming the 10 mph baseline for the .300 Winchester Magnum, and a distance of 400 yards where the full-value wind drift would be 10 inches, you can adjust the value to a certain percentage of that number based upon the cosine of the angle. Let’s say that 6x6 elk is standing at 400 yards, with the wind blowing at 45 degrees from your left, or somewhere between 10 and 11

o’clock on the dial. The math would work like this:

Sin45°, or, 0.707 x 10 in.(full value)=7.1 inches

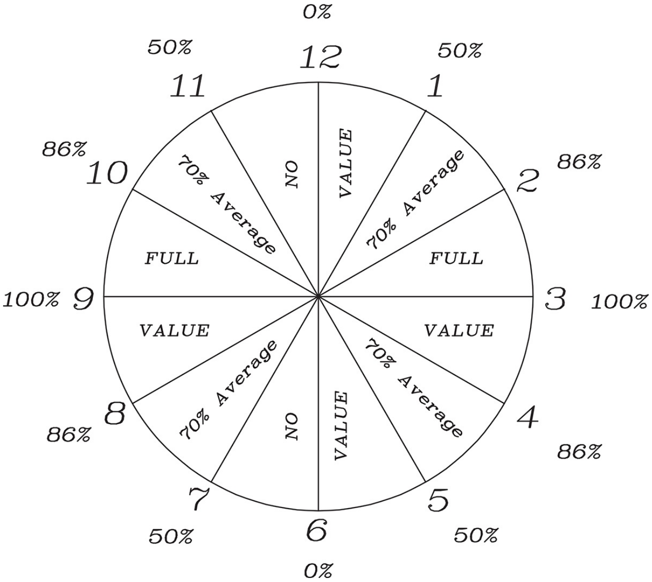
Change that wind position to exactly 10 o’clock on the dial and you’ll find the wind value will increase to 86 percent of the full-value wind effect.

Sin60°, or 0.866 x 10 in.(full value)=8.7 inches

You can simplify this a bit for field purposes, as winds are rarely a static

value, and may change slightly within a matter of seconds while lining up the shot. Taking an average of wind direction, and based on the sine functions of the angle, you can arrive at a basic chart that is easy to remember in the field.

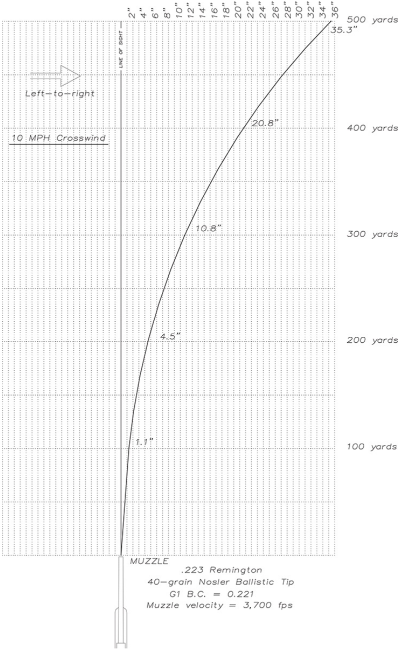
SINE WIND VALUES



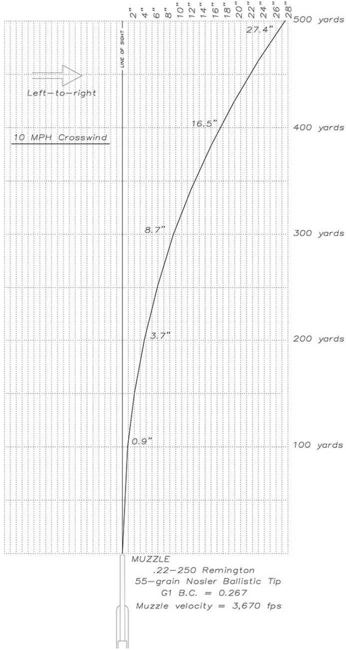
This concept, combined with a baseline wind chart, will allow you to place your shots much more accurately in the field than "Kentucky windage" ever

would. You’ll need to prepare a wind drift chart for each of your chosen calibers, and for each bullet/velocity combination you use within that caliber. When it comes to long-range shooting and “bucking the wind” (to use the vernacular) the bullets with the best BC values will keep the wind deflection to a minimum. If you like to use the semi-spitzer, round-nosed, or flat-base bullets (as I often do) the wind will present more of a problem, as the BC values drop significantly. The longer time of flight and drop in velocity will allow the

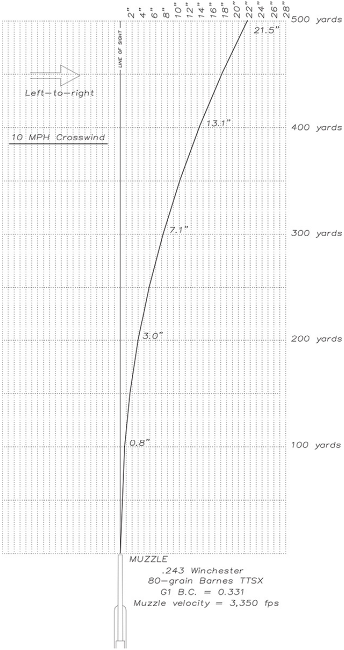
crosswind to have more time to work on the bullet. My example, based around the .300 Winchester Magnum and a sleek 180-grain bullet, is one that does rather well in the wind. Let’s take a look at the same idea for a few different calibers, with popular bullet choices, to understand why certain cartridges have been touted as good long-range choices.

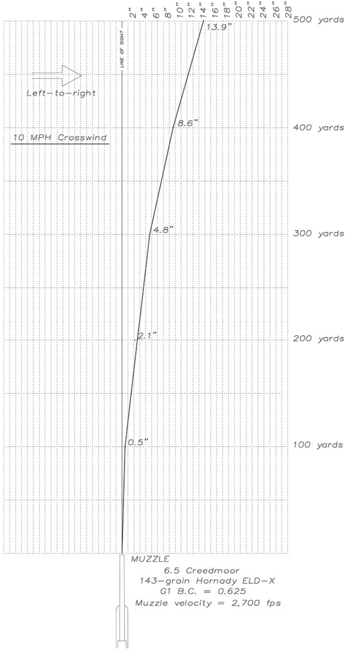


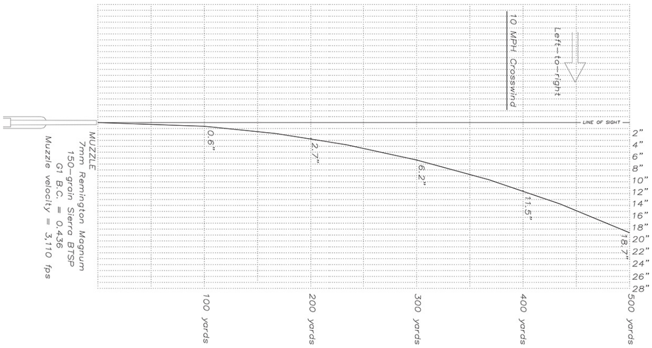
2"
4"
6"
8"
10"
12"
14"
16"
18"
20"
22"
24"
26"
28"
30"
32"
34"
36"
500 yards
400 yards
300 yards
200 yards
100 yards
LINE OF SIGHT
Left-to-right
10 MPH Crosswind
35.3"
20.8"
10.8"
4.5"
1.1"
MUZZLE
.223 Remington
40-grain Nosler Ballistic Tip
G1 B.C. = 0.221
Muzzle velocity = 3,700 fps



2"
4"
6"
8"
10"
12"
14"
16"
18"
20"
22"
24"
26"
28"
500 yards
400 yards
300 yards
200 yards
100 yards
LINE OF SIGHT
Left-to-right
10 MPH Crosswind
27.4"
16.5"
8.7"
3.7"
0.9"
MUZZLE
.22-250 Remington
55-grain Nosler Ballistic Tip
G1 B.C. = 0.267
Muzzle velocity = 3,670 fps


10 MPH Crosswind
Left-to-right
LINE OF SIGHT
MUZZLE
100 yards
200 yards
300 yards
400 yards
500 yards
2"
4"
6"
8"
10"
12"
14"
16"
18"
20"
22"
24"
26"
28"
0.8"
3.0"
7.1"
13.1"
21.5"
.243 Winchester
80-grain Barnes TTSX
G1 B.C. = 0.331
Muzzle velocity = 3,350 fps


10 MPH Crosswind
Left-to-right
LINE OF SIGHT
MUZZLE
100 yards
200 yards
300 yards
400 yards
500 yards
2"
4"
6"
8"
10"
12"
14"
16"
18"
20"
22"
24"
26"
28"
0.5"
2.1"
4.8"
8.6"
13.9"
6.5 Creedmoor
143-grain Hornady ELD-X
G1 B.C. = 0.625
Muzzle velocity = 2,700 fps



You can see the difference in performance, and how even though some of the lighter cartridges start out with a much higher muzzle velocity, their bullets, with lower BC figures, simply will not stand up to the wind as well as the high BC bullets. Now, the 7mm Remington Magnum is a good choice for

a long-range hunting cartridge, but take a look at the figures for that 6.5 Creedmoor. There seems to be something magical about the 6.5mm bullet; it possesses a good balance of sectional density and ballistic coefficient, and comes in quite a few cartridge choices that are easy on the shoulder, yet generates enough muzzle velocity to work very well for long-range work. Depending on your hunting situation, you’ll want to look for the bullet that best serves your needs, but if you feel your ranges could exceed 300 yards, the higher

BC bullets will make your shots in windy conditions much easier. Let's address some of the points regarding good wind bullets briefly.

HUNTING BULLETS AND WINDY TERRAIN

Most of the bullets that behave well in the wind have a common trait: a G1 BC above .500. In some cartridges, the common twist rate prevents the use of a bullet with a BC figure this high, and that's a good indicator of why they're not often chosen for long-distance shooting. To be clear, I'm still talking hunting

cartridges and bullets, so the requirements also include the terminal phase; we’ll get to some target bullets in just a bit. As mentioned, I’ve long been a fan of the Swift Scirocco II, as the bullet is very uniform and holds together well at a wide range of impact velocities. I’ve had excellent accuracy with it in a variety of calibers, and its high BC values (for most calibers) make it a good choice. The bullet’s bonded core and thick jacket give me a bunch of confidence if I’m holding a magnum caliber in hand and the shot is close. Some of the thinner jacketed

bullets, which perform equally well in the wind, will make a bit of a mess on the close shots. The Nosler AccuBond has certainly proven itself in the hunting fields, too, as has the Ballistic Tip. Both have a high BC for windy conditions. The Ballistic Tip makes a great deer bullet (especially in the high BC, heavy for caliber slugs) and the AccuBond has a great reputation for its terminal ballistics. Yet, I really like the AccuBond Long Range line of bullets, which have a steeper boat tail, and revised ogive to give an even higher ballistic coefficient.

The new 142-grain 6.5mm ABLR has a G1 BC of 0.719, and the .30-caliber 210-grain bullet a BC of 0.730! There’s a pair of winners if I ever saw them, blending all the attributes of a great hunting bullet: good in the wind, decent trajectory, and solid terminal performance. Fans of the .270 can get the 150-grain ABLR with a B.C. of 0.625, and the 7mm crowd has three choices — 150, 168 and 175 grains, with G1 BCs between 0.611 and 0.672. Bullets like these are changing the game, for a .270 Winchester with the ABLR is certainly not your grandfather’s gun, and

makes a perfectly viable elk rifle, even shooting across windy canyons.

The Nosler AccuBond Long Range 142-grain 6.5mm bullet.

Sierra, famous for the MatchKing target bullet, has some offerings in the

GameKing line that provide a good hunting BC for windy country. The 175-grain 7mm and 200-grain .308 bullet work very well, and while they are definitely heavy for caliber (check your barrel's twist rate!), they minimize the effects of wind deflection while offering enough sectional density to get the job done neatly.

Berger is one of those companies who've staked their claim in the long-range game, and they've done it well. Walt Berger started a company based upon benchrest precision, and it has

evolved into producing some of the most innovative projectiles for both hunting and target shooting ever designed. You’ll be reading more about these bullets in the target bullet section, but Berger has some damned fine hunting bullets as well. Almost all of the Berger offerings are sleek, boat-tailed affairs, with the VLD, or Very Low Drag bullet being the flagship of the hunting fleet. The VLD is accurate, and performs well on game, in addition to sporting a profile that resists wind deflection. However, Bergers tend to be considerably longer than some of

the more traditional hunting bullets, and can pose a challenge when it comes to staying within the SAAMI maximum length and functioning through normal-sized magazine boxes. However, if you can get them to function properly through your rifle, you’ll find you’ve got serious medicine in your hands. If you’re serious about a high BC bullet, take a look at Berger’s Extreme Outer Limits Elite Hunter line, designed for true long-range hunting applications. Note, these do require a fast twist rate. They are heavier than normal, to obtain that high BC

figure and resist crosswind deflection. The .277-inch diameter EOL bullet is 170 grains, and the 7mm is 195 grains. Serious business for certain, and though you may not have good results with a pre-’64 Model 70, long-range hunting requires specialized gear. Odds are you’re going to be looking into a specialized rifle for this style of hunting. I know serious sheep hunters who’ve built rifles just to handle the longest bullets to be able to connect on those long shots.

For small-bore rifles like the .223 Remington and .22-250 right up through

the 6mm, wind plays a more dramatic role in the hunting fields, especially with smaller targets like prairie dogs or woodchucks. The G1 and G7 BC values drop off in these cartridges, largely due in part to the weight of the bullets, and though they may be of similar geometry to their larger counterparts, they are more susceptible to wind drift. Despite having a muzzle velocity of 750 fps faster than the .300 Winchester Magnum, the 40-grain Nosler Ballistic Tip as loaded in .223 Federal Premium ammunition has twice the wind deflection at 400 yards

than the .30 caliber 180-grain bullet. Even at 200 yards, the .223 Remington drifts 4.5 inches in a 10 mph crosswind, which will definitely cause a miss on a prairie dog-sized target. Even the .22-250 Remington, which has a great reputation as a flat-shooting round, drifts almost 4 inches at just 200 yards when using a muzzle velocity similar to the .223, but with the heavier 55-grain Ballistic Tip. Accordingly, wind deflection must be known and accounted for if you want to hit those little flea-ridden varmints. By increasing the BC figures for either of

these cartridges, you can reduce the wind deflection and make your life easier.

Berger’s Extreme Outer Limits bullets.

TARGET BULLETS AND 1,000 YARD WIND

I personally don’t take shots at unwounded game beyond 400 or, under absolutely optimum conditions 500 yards, but I’m only speaking for myself. If you routinely practice past that distance, and are comfortable, I’m not one to disagree. However, I know my own limitations, and between 400 and 500 yards things get too iffy for my comfort level. Shooting targets, now that’s a whole different ballgame! I absolutely love to ring steel out to 1,500 yards or more, if the

opportunity affords. Here in the Northeast, those opportunities are limited, but I’ve spent some time in Texas where the vast expanses of land and broken terrain allow for a safe shooting condition, with targets out to 1,800 yards and more. I’ll warn you upfront: check your ego at the door when the distances get to four figures, as it can be a very humbling experience. I’ve seen excellent shots in the game fields who’ve become frustrated, flustered and downright pissed when it came to hitting a 1,200-yard steel gong.

The Cutting Edge Lazer, a great target bullet. Due to its length, CEB recommends single feeding.


ssaro Ballistic Labor
Match
ustom Handloading
518588-8070
www.MBLammo.com

The Hornady ELD Match in the author’s 6.5-284 Norma.

Invariably, knowing the exact drop of your cartridge is very important at those four figure distances, as is proper shooting form, but man! — the wind becomes difficult. At 1,000 yards, some of the highly popular target cartridges have gone subsonic, and are travelling through the ‘dirty air’ that affects a bullet between Mach 1.2 and the speed of sound. Even if the bullet remains supersonic, it has slowed down

considerably and has had a much longer time of flight than has a hunting bullet, so the wind has a greater opportunity to work on the bullet's flight path. While the Scirocco is a great hunting bullet, perhaps you would be better served by a match-grade target bullet. There are many available, from the Sierra MatchKing — which has pretty much become the benchmark bullet for this application — to the Berger target projectiles and their fantastic J4 jackets, to the Lapua Scenar and Scenar-L, and the Cutting Edge MTH with its Seal-Tite band that will give

some of the best velocities available. All of these have the capability of producing excellent long-range accuracy, provided you can do your part to take advantage of their wind drift resistant capabilities. I’ve had great results with the Hornady ELD-Match bullet in my 6.5-284 Norma on targets out to 1,400 yards. I took my time, testing the rifle’s accuracy out to 500 yards where, with my handloads, the rifle can and will maintain ⅓ MOA, and used this bullet to test my own shooting abilities out to four-figure distances. At 140 grains, the ELD-Match has a G1 BC

of 0.610, more than acceptable for targets at the distances I’ve described. While the muzzle velocities were not remarkable, it did give extremely uniform results. My particular rifle gives better velocities using a flat-base 140-grain bullet, but the accuracy using boat tail match-grade bullets is unparalleled, at least in my barrel. Such accuracy makes life much easier when attempting to ring steel at 1,000 yards and more. Accordingly, this rifle ‘wears two hats’ in that, for my hunting loads, I actually prefer the balance of trajectory and terminal

performance of the premium flat-base 140-and 160-grain slugs, but when it

comes to target work, the higher BC bullets get the call.

A dope card for the 6.5-284 Norma, from the Hornady 4 Degrees of Freedom Ballistic Calculator, using the 140-grain ELD-Match:

Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	ComeUp (MOA)	Wind Drift (in.)	Wind Drift (MOA)	Spin Drift (in.)	Spin Drift (MOA)	TOF (sec.)
0	2,580	2,070	-1.75	0	0	0	0	0	0
25	2,545	2,015	-0.2893	-1.1052	0.0348	0.1329	-0.0027	-0.0102	0.0293
50	2,511	1,961	0.8337	1.5923	0.1396	0.2666	-0.0108	-0.0206	0.0589
75	2,477	1,908	1.6128	2.0536	0.3158	0.4021	-0.0246	-0.0313	0.089
100	2,443	1,857	2.0384	1.9467	0.5649	0.5395	-0.0441	-0.0421	0.1195
125	2,410	1,806	2.1003	1.6046	0.8886	0.6789	-0.0696	-0.0532	0.1504
150	2,376	1,756	1.7875	1.1381	1.2887	0.8205	-0.1013	-0.0645	0.1817
175	2,343	1,707	1.0913	0.5955	1.7665	0.964	-0.1392	-0.076	0.2135
200	2,310	1,660	0	0	2.3239	1.1097	-0.1837	-0.0877	0.2458
225	2,277	1,613	-1.4988	-0.6362	2.9628	1.2575	-0.2347	-0.0996	0.2785
250	2,245	1,567	-3.4157	-1.3048	3.6849	1.4076	-0.2927	-0.1118	0.3116
275	2,212	1,522	-5.7625	-2.0012	4.4918	1.5599	-0.3577	-0.1242	0.3453
300	2,180	1,478	-8.5537	-2.7229	5.386	1.7145	-0.4299	-0.1369	0.3794
325	2,148	1,435	-11.8016	-3.4678	6.3697	1.8717	-0.5097	-0.1498	0.4141
350	2,116	1,392	-15.5195	-4.2346	7.445	2.0314	-0.5971	-0.1629	0.4493
375	2,084	1,351	-19.7216	-5.0224	8.6144	2.1938	-0.6924	-0.1763	0.485
400	2,052	1,310	-24.4248	-5.8314	9.8806	2.359	-0.7958	-0.19	0.5213
425	2,021	1,270	-29.6425	-6.6609	11.2458	2.527	-0.9076	-0.2039	0.5581
450	1,990	1,231	-35.3907	-7.5107	12.7126	2.6979	-1.0279	-0.2181	0.5955
475	1,958	1,193	-41.6884	-8.3816	14.284	2.8718	-1.1572	-0.2327	0.6335
500	1,927	1,155	-48.5516	-9.2734	15.9625	3.0488	-1.2956	-0.2475	0.6721
525	1,896	1,118	-55.9986	-10.1864	17.7517	3.2291	-1.4434	-0.2626	0.7113
550	1,865	1,081	-64.0494	-11.1213	19.6555	3.4129	-1.6008	-0.278	0.7512
575	1,834	1,046	-72.7245	-12.0786	21.678	3.6004	-1.7681	-0.2937	0.7918
600	1,802	1,010	-82.0449	-13.0589	23.8232	3.7919	-1.9455	-0.3097	0.833
625	1,771	975	-92.0322	-14.0626	26.0954	3.9874	-2.1333	-0.326	0.875
650	1,740	941	-102.714	-15.0911	28.4996	4.1873	-2.3319	-0.3426	0.9177
675	1,709	908	-114.111	-16.1446	31.0398	4.3916	-2.5414	-0.3596	0.9612
700	1,677	875	-126.251	-17.2243	33.721	4.6005	-2.7623	-0.3769	1.0055

View a text version of this table

Points to Remember About Wind Deflection

More than gravity, wind deflection can cause errant shots, and at ranges out beyond 300 yards must be accounted for.

Wind is most definitely a variable, and knowing how your bullet will perform in a variety of different wind conditions will vastly improve your marksmanship skills.

Using a bullet of the highest BC value possible will definitely reduce the effects of the wind.

Higher muzzle velocities (read shorter time of flight) will also deny the wind the opportunity to push your bullet off course.

Inside 200 yards, the wind has very little effect in a hunting situation, rarely pushing the bullet out of the vital area on a big game animal.

On more than one occasion I’ve used match-grade bullets to develop a load for a rifle, assessing what I feel to be the true accuracy potential, and adjusting fire

accordingly when choosing a hunting bullet. I feel comfortable saying this: if you intend to use a rifle for target work, especially long-range target work, you’re best served by choosing two or three different types of high BC match bullets and trying them in your rifle. These designs — whose job is to punch paper targets or ring steel discs — will invariably resist wind deflection best. As the distance increases, they will retain their energy and keep the time of flight to a minimum.

HANDGUNS, LEVER GUNS AND WIND

The idea of time-of-flight being a controlling factor in wind deflection is important; it explains why so many of the handgun bullets can easily get away with a round- or flat-nosed projectile: they just aren’t out there in the atmosphere long enough to be affected. Same can be said for many of the ‘woods guns,’ like the venerable .30-30 WCF and .32 Winchester Special, guns typically employed for shots within 100 to 150 yards. You can see from the above charts

that wind will have very little effect at those distances. If you do choose to use one of these style cartridges, or even a hunting handgun out to similar distances, you will begin to understand why the Hornady LeveRevolution ammunition took off so well: the soft, rubbery tip is safe to use in a tubular magazine, but more importantly the BC values dramatically increased. This gives not only a much more desirable trajectory, which immediately jumped out at most consumers, but also greatly reduced wind deflection.

I mentioned earlier in this chapter that I use the Hornady 180-grain round-nose InterLock in my .300 Winchester Magnum, especially in the forests of the Catskill and Adirondack mountains. I’ve had fellow hunters look at me as if I’d lost my mind; with so many good spitzer boat tails available, why in the world would I choose that throwback style bullet? Well, I like the way it imparts energy, but looking at it in a different light, I’m really not concerned about wind deflection or long-range trajectory. I zero this particular load at 150 yards,

which gives me the ability to hold dead on out to 200 yards, and within those ranges I’m not concerned about drop or wind drift since the time of flight is so short that the bullet will strike the vital area even on the windiest of days. The round-nose bullet hits hard, penetrates well, and is accurate in my gun.

Hornady LeveRevolution ammo offers improvements in both trajectory and wind drift values.

This theory also applies to many of the African safari bullets — even those that may be loaded in a cartridge like the .300

Winchester, or others that are capable of long-range work. In Africa, a shot past 200 yards is the exception, not the rule, unless you’re hunting one of the areas like the Kalahari Desert or the swamps of Bangweulu, and these are specialized affairs to begin with. As a result, most of the Professional Hunters I know prefer the round- or flat-nosed projectiles for the ‘bushveld’ shots. Yes, I realize I told you about that eland that stood at 400 yards, with no possibility of getting closer, but that was a rare exception, and I was prepared for that by making a dope card

for my .375 H&H. For certain, most dangerous game is taken inside of 150 yards, as the PH wants an accurately placed shot, and to impart all the energy available into an animal. Most of the double rifle calibers like the .450 Nitro Express, .470 Nitro Express and .450/400 3-Inch Nitro Express, are designed for short-range work, and will rarely be used past 150 paces, plus the ammunition is more often than not loaded with round- or flat-nose projectiles. The wind deflection values of these cartridges do look

abhorrent past 200 yards, but such ranges don't typically come into play.

The .470 Nitro-Express, a short-range cartridge with plenty of horsepower.

On the flip-side of that coin are some big bores that can be used as longer-range

rifles. Certainly the .375 H&H falls into this category, as it will generate respectable muzzle velocities, especially with some of the new bullet designs between 230 and 260 grains, yet can be used at distances out to 400 yards and beyond. That cartridge represents one of the few ‘do anything, anywhere’ choices, with enough horsepower to handle the heavyweights like elephant, buffalo, grizzly and hippo, but makes a decent choice for elk and moose when loaded with the higher BC bullets. A 260-grain Nosler AccuBond performs very well in

windy conditions, maybe not as good as a fast .30 caliber, but certainly workable for a rifleman who practices with it. This bullet has a G1 BC of 0.473, which makes it comparable to many of the .30 caliber hunting bullets, and you'll see from the graph that the 400-yard wind drift is only 12.5 inches in a 10 mph wind; not too far off from the .300 Winchester's 10.0 inches. Many hunters are surprised when they actually look at the ballistics of the .375 H&H, as they eventually recognize (as I did) that the trajectory mimics the .30-06 Springfield,

only on a larger scale. Couple that with the fact that the 300- and 350-grain bullets can be employed for dangerous game work, and you’ll see why so many hunters have come to rely on the venerable cartridge for so long, and why it remains as popular as it is to this day. The .375 Ruger, its ballistic twin, is fully capable of the same accolades. You can also understand why a hunter who pairs his .30-06 deer rifle with a goof .375 bore will be very comfortable: the two behave very similarly in the field, the difference being the payload delivered. Should you

own a .375, and want to use it for elk, moose, or other distant shots, look to bullets like the 260-grain AccuBond or the 235-grain Cutting Edge Raptor and you’ll have a relatively flat-shooting, wind defiant big bore.

SECTION III

TERMINAL BALLISTICS

SECTION III: **GUNDEX®**

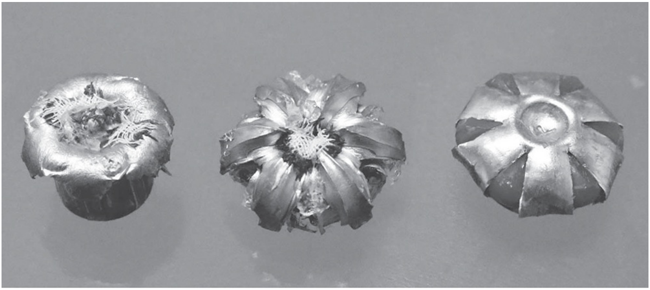
CHAPTER 15

CHAPTER 13 TERMINAL BALLISTICS OVERVIEW

That little blob of metal, so content in its metallic case, has been sent screaming down the barrel, spinning until it's dizzier than a two-year-old on sugar, sailing through the air faster than, well I was going to say a speeding bullet, but, it's going pretty damned fast. Then, instantly,

violently, the journey ends. At the gun range it just rips paper and meets its untimely demise in a sand bank or dirt berm. Perhaps it smashed through hide, bone and vital tissue, putting dinner on the table for a family all winter. Or maybe it was built like a race-car, and got to fly long and high, only to end in the sweet ringing of steel. Best of all, that bullet may have saved someone’s life. Whatever the case, the end of a bullet’s life is an important part of our study, what we call terminal ballistics — what happens when it impacts.

Swift A-Frame recovered from a Zambian Cape buffalo bull.



Expanded handgun bullets have come a long way today.

Whether in a defensive situation, or on a dangerous game hunt, there are times when the construction and terminal performance of a bullet means life or death. In the case of hunting bullets, you want a quick, humane kill — after all, the bullet’s job is to reach the vital organs to

destroy tissue. No matter how many trajectory charts you’ve memorized, no matter how many lines-per-inch the checkering on your AAA Circassian walnut features, it is the bullet, and only the bullet, that touches a game animal and delivers the death blow.

At this stage of the game you’ve managed to place the shot where it belongs, and now need to consider what’s going to happen after impact. Will the bullet penetrate sufficiently? Will it expand properly? Was it of suitable construction to handle the task at hand?

Did you choose the proper type of bullet to meet the requirements you need? All these questions and more fall under the heading of terminal ballistics.

In this section, the handgun will receive much more attention than it has previously. While the exterior ballistics of handgun bullets aren’t nearly as complex as that of rifles, the terminal ballistics of a handgun are very interesting. Handgun hunting bullets have come an awful long way, and there are some absolutely incredible personal defense choices out there, too. Their

performance needs to be analyzed to best choose a handgun caliber, as well as settle some old arguments.

Rifle bullets have changed for the better as well, having many new designs available. Some of these designs are a far cry from the cup and core bullet of our grandfathers’ era, and deliver some outstanding performance, almost forcing us to rethink the old cartridge and caliber recommendations. These innovations implore you to take a new look at how much cartridge/bullet is really needed to get the job done. I am always intrigued

about new bullet designs, and I’ve had the opportunity to test some of these around the globe, on animals small, medium and large.

Author with a bull elephant taken in Zimbabwe. With an animal of this magnitude, terminal ballistics are a matter of life and death.

There is much demand placed upon the rifle bullets of today. You expect your modern rifle bullet to be a death-ray. If you do our part in holding the rifle on the right spot and squeeze the trigger properly, you expect instantaneous results. The bullet needs to be accurate, retain almost all of its energy downrange, expand well enough to create a huge wound channel, and penetrate deep

enough to destroy the vitals from any angle. Oh, and you want it cheap, too! No worries!

Well, the bullets of today can meet most of those parameters, but not all. There are some that will certainly deliver the goods, but the materials and manufacturing costs are higher than the bullets of yesteryear. While some of the tried and true hardcast lead and cup and core bullets still perform wonderfully in certain situations, there are those times when the cost of a hunt or the scarcity of a coveted tag warrant the investment in

the best projectile money can buy, no matter which of the attributes listed above is most important.

The birth of the premium bullet industry hearkens back to 1948 in Canada, when John Nosler experienced terrible bullet failure while trying to relieve a large-bodied moose of his life with a .300 Holland & Holland Magnum. The cup and core bullets that Nosler was using simply weren’t strong enough to handle the high impact velocity of the Super .30, and had prematurely expanded on the moose’s shoulder, giving poor

penetration. His idea of a dual-core bullet separated by a copper partition really set the hunting world on its ear, and created an entire market for premium projectiles. Fast forward to the 21st century, and you have monometal bullet designs that would certainly make my grandfather cock an eyebrow. Some of these newcomers use a funky sort of nipple at the front end to cause trauma via a cavitation bubble, delivering straight-line penetration and a cylindrical core of trauma. Some designs, like the aforementioned Nosler Partition, have

been with us for decades, and have their devout followers.

John A. Nosler. Photo courtesy Nosler.com

Whatever the case, there is now a proper tool for the job at hand. You, as the hunter, shooter and consumer, need to be honest with yourself about the requirements of your shooting situation to choose a bullet that will give you the results you’re after. We will start the study of terminal ballistics by dealing with a bit of bullet history, and how bullet performance so heavily influenced the reputation of the cartridges themselves. We’ll then examine how the projectiles of

the 21st century could and should change the way we think about cartridge requirements.

The Nosler Partition is still the benchmark by which all modern bullets are measured. Photo courtesy Nosler.com

CHAPTER 14
THE HISTORY OF TERMINAL BALLISTICS

The first projectiles for the firearm were round lead balls, slightly smaller than bore diameter, to be ‘patched’ for a tight seal. Lead was the chosen material, not for its durability upon impact, but for its malleability in forming the projectiles. Lead is easy to work and shape, melts at

a relatively low temperature, and is plentiful. This was perfect for the early users of the cartridge guns, as many firearms were sold with a set of molds of appropriate caliber and bullet weight for that firearm. Think of the buffalo hunters on the Great Plains, hunting all day and sitting by their campfire at night, melting lead and casting their own lead bullets for the next hunt. However, lead has several shortcomings, especially with modern firearms and propellants.

Author with bull elephant, taken in Zimbabwe with a Woodleigh Hydro Solid.

Cast lead bullets work fine at .38 Special velocities.

Your goal as a hunter (we'll get to the self-defense bullets soon enough), is to deliver a quick, humane kill, to minimize the suffering of the game animal. For most of your hunting, with the exception

of solid bullets or a shot column from a shotgun, you depend on the bullet to create massive hemorrhaging by destroying as much vital tissue as possible. The expansion of a bullet — if it is designed to expand — creates hydraulic shock, which destroys tissue as well. Now, when a material as soft as lead impacts hide, bone, and water-rich flesh at an appreciable velocity, you can have very rapid expansion. Your projectile will certainly meet enough resistance to flatten a round ball, or rapidly deform the meplat of a lead

bullet. So the lead ball or bullet must be of sufficient weight and diameter to properly penetrate into an animal’s vitals in order to guarantee a quick kill, and the velocity must be kept to a reasonable level, say below 2,200 fps. Even then, the bullet can exhibit penetration problems if the shot is too close.

The stories of Frederick Courteney Selous from the late 19th century are illuminating. Selous would hunt elephants with a muzzleloading four-bore rifle stoked with a lead ball weighing ¼ pound, propelled by over 500 grains of

black powder. That gives you an idea of how the early projectile directly affected the choice of bore diameter; you simply needed to compensate for a lack of penetration with sheer mass.

The military-approved full metal jacket.

At moderate velocity typical of the .30-30 Winchester or .45-70 Government, or most of the classic handgun cartridges like the .38 Special and .45 Colt, a lead projectile will work well, giving a good blend of expansion and penetration. Many of these cartridges are still loaded with lead projectiles today, and they

perform superbly. For some of the faster cartridges like the .44 Magnum, lead bullets can be hardened by adding a specific amount of antimony to the molten lead while casting, resulting in a harder alloy and better terminal ballistics.

In light of the velocity increases that smokeless powder brought to the table, there needed to be an advance in the construction of projectiles. It was Lt. Col. Eduard Rubin of Switzerland who, in 1882, had the ingenious idea of jacketing the lead bullets in a layer of copper — a metal hard enough to avoid the issues

associated with heavy lead deposits in the barrel, yet soft enough to work perfectly with the steel rifling of the barrel. Rubin completely covered the spitzer projectile, leaving no exposed lead, creating the first ‘full metal jacket’ or FMJ as we all know it today.

The lead bullets that had previously been used in combat had such a terrible effect on soldier’s bodies. Think about the photos and accounts from the Civil War, and how some of those large caliber lead bullets and balls would not only inflict horrible flesh wounds, but would

sometimes tear limbs off at the bone. The advent of the FMJ made total sense as a weapon of war. Indeed, many countries of the world felt that the horrific wounds of injured soldiers could be minimized by the use of the non-expanding projectiles. The Hague Convention of 1899, in Declaration III, specifically prohibited the use of any expanding projectiles in international warfare, though many incorrectly attribute this prohibition to the Geneva Convention. For the record, the United States did not agree to the treaty. This decision included so-called ‘Dum-

Dum’ bullets: those FMJs that had any exposed lead, or a cross-slot cut into the nose for expansion. (An interesting note is that Dum-Dum bullets were named after the British military facility near Dum-Dum, West Bengal, India. It was here that Captain Neville Bertie-Clay developed the Dum-Dum bullet, an expanding projectile designed for the .303 British cartridge, with a radical hollowpoint. The expansion of this bullet could be best described as violent, and I can only imagine the devastating result of using this projectile in combat.)

The result of adding a copper jacket to the traditional lead projectile completely changed the hunting world as well. Not only could these new projectiles be driven to much higher velocity and with fantastic accuracy, but by manipulating the amount of exposed lead at the nose, or meplat of the bullet, the amount of expansion could be *controlled*. This allowed ammunition manufacturers to ‘tune’ the bullet to the velocity of the cartridge, and better control the expansion/penetration ratio. The method of drawing a copper cup around the lead

core results in what I have referred to elsewhere in this book as a ‘cup-and-core’ bullet.

There were failures early on. The copper cup would often separate from the lead core upon impacting a game animal, and penetration was severely affected. Attempts were made to better keep the bullets together during the terminal ballistics phase. Remington’s 1939 Core-Lokt bullet used a cannelure that stepped the copper jacket into the lead core to better keep the bullet in one piece. A tapering copper jacket, thicker toward the

rear, made an appreciable difference in controlling — that is, slowing — the amount of expansion so that the necessary penetration could be obtained.

In the first half of the 20th century, hunters pretty much had two choices, especially for the dangerous game of Africa: a soft-point bullet with a bit of exposed lead at the nose with a copper jacket that covered the remainder of the bullet, or a full metal jacket bullet — commonly referred to as a ‘solid’ — which offered no expansion whatsoever, but would provide fantastic penetration

against those animals with extremely thick hides and huge, tough bones. There were volumes of material written about the effectiveness (or lack thereof) of the waves of new cartridges being released by British, German, and American ammunition and firearms companies. If you are a fan of firearms and cartridge development (and by picking up this book I would assume you are) there are plenty of articles and books available that give a good glimpse into the situation at various points throughout the first half of the 20th century. People like Elmer

Keith, Jack O’Connor, John ‘Pondoro’ Taylor, W.D.M. Bell, and John Hunter authored many of these works, and these gentlemen all had huge amounts of hands-on experience with the tools of their day. In reading their works one can get a definite feel for the opinions they garnered through trial and error, and these opinions are still heralded today.

However, the reader must also appreciate the fact that many of the opinions generated by these now-famous authors were directly influenced by the terminal performance of the projectiles of

their era. One of my favorite volumes, written by John ‘Pondoro’ Taylor — an Irishman who tramped all over southern and eastern Africa — is *African Rifles and Cartridges*, a treatise on firearms and cartridges commonly used throughout the Dark Continent from 1920 until 1948 or thereabouts. Taylor had, according to his own accounts, used the vast majority of popular cartridges, from the .22 Long Rifle, up to and including the behemoth .600 Nitro Express. He recounted his experiences with those cartridges on all sorts of African game, from the

diminutive antelope up to the gigantic elephant. While few may have the opportunity to hunt Africa, this cross-section of game taken by Taylor includes many that are similar to our North American species.

Semi-jacketed .44 Remington Magnums.

Cape buffalo require a stout bullet, and proper shot placement.

Jack O’Connor was a fantastic author, known for championing the .270 Winchester, and was a proponent of the lighter calibers using bullets at higher velocities. Elmer Keith, an Idaho rancher

with an extensive background in firearms, was responsible for the development of several highly popular handgun cartridges, as well as participating in the development of rifle cartridges that went on to influence future developments. These two gentlemen were both very well respected, yet had diametrically opposed views on what made a suitable hunting cartridge for various species. Keith believed in much heavier bullets than did O’Connor. But I firmly believe that their respective points of view were inarguably based on the

terminal performance of the projectiles from their era much more than the potential of the cartridges by which they so strongly swore.

Walter Dalrymple Maitland Bell, a Scotsman whose adventures in early 20th century Africa are heralded to this day, was a proponent of the use of small-bore rifles (the 7x57mm Mauser being the most used) for big game, especially on the 1,000+ elephants he took in his hunting career. Bell, who was an excellent shot, especially under the pressure of being in close proximity of

truly dangerous game, made the claim that his “barrel had never been polluted by a soft-point bullet.” He came to rely solely on full metal jacketed bullets, which had the nose portion strengthened by steel, placed under the layer of copper gilding metal. While I don’t think that any Professional Hunter alive today would recommend or even accept the 7x57mm Mauser as an appropriate dangerous game cartridge, Bell was not a ‘hunting client’ in today’s sense. He had no legal requirements regarding rifle caliber, and was literally in uncharted

waters with respect to ballistic boundaries. Bell found that 173 grains of bullet properly placed would work just as effectively as 500 grains. If either bullet were placed incorrectly, Bell contended, they were equally ineffective. We can agree that a cartridge as small as the 7mm Mauser is not the best choice for dangerous game, but Bell’s point was that a bullet, if properly constructed, could amaze a hunter as to its actual capabilities. In a very short period of time, the four-bore lead cannonball weighing in at ¼ pound had effectively

been matched with a 173-grain steel and copper jacketed 7mm slug. The terminal ballistics experimentation of Bell (who also used a 6.5x54mm Mannlicher-Schoenaur and a .318 Westley Richards) gave quite a bit of insight into the importance of bullet construction and its correlation to terminal ballistics.

All of these hunters had an irrefutable effect on the reputations of our favorite cartridges, on both ends of the spectrum. And many of those endorsements, based on the projectiles available to them at the time, carry on to this day. Today,

however, some of these viewpoints need to be revised.

The cup-and-core bullets of the first half of the 20th century were tweaked in many different ways to achieve the consummate blend of expansion and penetration. The Remington Bronze Point was an early release which used a hollowpoint design, capped with a sharp, bronze tip that would not only prevent the meplat of the bullet from being battered under recoil, but would act as a wedge to initiate expansion. It was met with mixed reviews. Some hunters found it to work

wonderfully, giving great expansion and hydraulic shock. Others reported that the bullet failed to give any expansion at all — acting just like a solid and giving caliber-size entry and exit wounds. Most folks just used the standard cup-and-core bullets, with varying levels of satisfaction.

All that changed in 1948, when John Nosler went moose hunting. His chosen rifle (and a fine one at that) was the .300 Holland & Holland Magnum, a perfect choice for the distances at which moose may be taken, and a caliber with an

excellent reputation for big game. I’m not sure which brand of projectile Nosler was using, but the story as I’ve heard it goes as follows. Nosler had a moose at relatively close range, and while he placed his shots well, right on the beast’s shoulder, the bullets just wouldn’t penetrate. His cup-and-core bullets, driven to a muzzle velocity of just over 3,000 fps, simply were breaking up on the tough muscles and shoulder bones of the huge moose. This left him perplexed. He knew he had done his part, and that there must be a better solution to the

problem of bullet construction. Once he got home, he put on his thinking cap and came up with an idea: a bullet divided in two, separated by a partition of copper, which would be made integral with the copper jacket. He took a copper rod of proper dimension, drilled out either end, inserted a lead core, and fashioned the front portion into a spitzer profile. The idea was to allow the front portion of the bullet to expand for the tissue destruction necessary for a quick kill, yet keep the rear portion intact for deep penetration. The idea worked perfectly, and the Nosler

Partition was born. It did exactly what Nosler intended, giving nearly the penetration of a solid, yet the front expanded properly. Naturally, the performance of this bullet caused it to catch on quickly and to this day the Nosler Partition remains a favorite of hunters around the globe.

Bell’s 7x57 Mauser.

Federal Premium’s .30-06 load, built around the 180-grain Nosler Partition.

What John Nosler really did was single-handedly kick-start what would become the premium bullet industry. The premium bullet designs that have come

onto the market have been nothing short of amazing. In the post-WWII years, many premium or boutique bullet companies popped up, once the raw materials became available once again. There were huge surpluses of powder, and some eager entrepreneurs began to show their wares, resulting in what are household names today: Joyce Hornady, Vernon Speer, Sierra Bullet Company, just to name a few. They gave us the projectiles that, while of standard construction, allowed hunters to develop their own handloaded ammunition with

reliable and predictable results. Over the decades, these companies would hone their crafts, and continue to push the boundaries of bullet technology.

The Barnes TSX is an update of the original model and is an all-copper hollowpoint.

The Barnes Bullet company dates back to the 1930s, when Fred Barnes was making his own custom bullets in his

basement. He sold the company three decades later and, following a succession of sales, the company ended up in the hands of Randy and Coni Brooks. The Brooks' kept Barnes on for a bit as a consultant, but it was they who had the revolutionary idea. Randy Brooks had experienced bullet failure in the past, and while he was sitting on a high perch in Alaska glassing for spring brown bear and thoughts wandering, he had an epiphany. As he explained it to me, he thought, why not take out the lead. The result: He had designed the all-copper

expanding X-Bullet, which solved the problem of jacket/core separation, and led to an entire school of thought known as the monometal expanding bullet. This was a huge development in terminal ballistics. The scored hollowpoint would open upon impact to form an X. The retained weight of the bullet was unprecedented. Brooks also developed a monometal solid for the African heavyweights that remains one of the best on the market even today.

Swift Bullets, hailing from Kansas, has also set an impressive benchmark in the

terminal ballistics world. Improving, if you will, on the partitioned bullet design, Bill Hober’s company uses a thicker jacket for their A-Frame bullet, as well as chemically bonding the jacket to the front lead core, further slowing expansion. The A-Frame is a great choice for thick-skinned animals, and is ideal for any critter smaller than elephant. When recovered from game animals it proves to hold its weight very well — often in the 90-95 percent range — and shows good expansion on the front end, displaying the classic A-Frame ‘rivet’ just behind the

partition. I’ve often described the Swift A-Frame as “meat-resistant,” meaning the more meat you hit, the greater the resistance to the bullet, the more the A-Frame will expand. On big game, such as bison and Cape buffalo, it will expand to around twice its caliber, yet on smaller game that number diminishes, often whistling clear through … still killing, yet not leaving you with a whole bunch of bloodshot meat. I especially like this bullet when using a big bore rifle, say a .375 or one of the .40 calibers, for hunting plains game in a dangerous game

block, or when chasing elk or moose in an area known to be inhabited by grizzly. Swift makes this bullet not just for the bolt-action rifles (in a semi-spitzer design), but in a flat meplat designed for use in the popular lever-action cartridges, as well as for the hunting revolver cartridges. Were I to choose just one bullet for all of my hunting beside the elephant, it would be the Swift A-Frame. I’ve used it on dozens of different species, and its terminal ballistics make it my personal favorite, even though I know

I’m giving up a little bit of ballistic coefficient.

Zambian warthog taken with a 400-grain Swift A-Frame in .416 Remington.

There are now many different bullet designs on the market that feature a sharp polymer tip, serving to act much like the Remington Bronze Tip I discussed earlier. The polymer tip of the bullet is designed to increase the ballistic coefficient yet, upon impact, the tip acts like a wedge, initiating expansion. The polymer tip has been incorporated into many different bullet designs, like the Barnes TTSX, the all copper hollowpoint with a tip to promote expansion; the Swift Scirocco II, a heavy jacketed boat tail bullet with a bonded core; and the

Hornady SST, a standard cup-and-core design. Nosler alone has three tipped models, the Ballistic Tip, AccuBond and E-Tip, and all three are constructed differently.

There are specially designed varmint bullets engineered to give an almost explosive terminal performance. These feature very thin jackets and soft lead cores, and are as frangible as can be, delivering all sorts of hydraulic shock. Some are hollowpoints, while others are polymer tipped, but all have come a long way toward their specific goal: creating

the ‘red mist” that varmint hunters are after.

Lastly, the most recent developments in big game rifle bullet technology are some real eye openers. The Woodleigh Bullet Company of Australia has released their Hydrostatically Stabilized Solid, a non-expanding monometal with a small cup at the nose. This bullet creates a supercavitation bubble, destroying tissue along the way, yet exiting at caliber dimension. This design worked perfect for me in Africa on game from impala to elephant, offering all the penetration

anyone would want, in addition to quick, humane kills.

The Pennsylvania-based company Cutting Edge Bullets produces monometal projectiles (either all-copper or all-brass) that are turned on a lathe for extremely tight tolerances. Their Raptor bullets are a hollowpoint design, available either with or without a polymer tip, and the ogive of the bullet is skived, so upon impact the front half breaks into little blades that cause the initial trauma in a star-shaped pattern. It’s a very interesting concept, and one that

has proven itself around the world for me.

Peregrine Bullets, hailing from South Africa, are producing a fine monometal bullet too, in several different configurations. One I find most interesting is the Bush Master bullet, which uses a bronze ‘plunger’ in the hollowpoint with a slight bit of air space underneath it. The plunger sits flush with the meplat of the bullet and, upon impact forces the bullet to expand as the air trapped inside the hollowpoint can’t be compressed, resulting in force that opens

up the nose of the bullet. Designed with a thick wall and an almost flat nose, the Bush Master imparts its energy much like a flat-nose or round-nose, yet retains almost all of its weight, making it a great design for truly big game like moose, bear, or any buffalo.

Hornady’s XTP.

As you can see, the rifle bullet has had a long and complex journey when it comes to terminal ballistics, and we haven’t yet cracked the surface.

Revolver and pistol bullets have gone through much the same development and

many of the designs I’ve described are offered in a handgun configuration. Bonded cores, thick jackets, monometals, skived hollowpoints; they’ve all made their way into the handgun bullet market. The lead pistol bullet of yesteryear still gives good performance, but today’s designers have imparted their wisdom to the handgun projectile so as to give some rather stunning results. The idea of jacketing a handgun bullet is as old as the jacketed rifle bullet itself. The same Hague Convention decree applied to handgun bullets, so the full metal jacket

bullet is certainly a popular configuration, and its terminal ballistics have been proven in a pair of World Wars. The still-popular “ball” ammunition offers no expansion whatsoever, but provides fantastic penetration. Ballistic engineers have long sought the consummate balance between bullet expansion and penetration, seeking to give just enough penetration to neutralize a threat, yet not too much, which could injure or kill unintended parties.

Barnes XPB, a great choice for the .357 Magnum.

There are some great pistol bullets that fit this bill using a hollowpoint design and varying jacket types. Some have the jacket locked in with a cannelure, others lock the copper jacket around the mouth of the hollowpoint. Some of these designs include the Hornady XTP and XTP Mag, Speer Gold Dot, and the Federal Hydro-Shok, Guard Dog and HST.

Monometal bullets have been adapted to a self-defensive role. The Cutting Edge Bullets line of Personal Home Defense ammunition comes immediately to mind, offering many of the same benefits of the

rifle bullets of same design: lighter throw weight and correlative higher velocity, stout construction, and reliable expansion. When it comes to a self-defensive handgun projectile, a flat trajectory is not a major concern, but accuracy and terminal ballistics are paramount.

On the hunting side of things, the evolution of the bullet has led to some impressive terminal performance. Yes, hardcast lead bullets, usually in a flat-point configuration will still make a dependable choice at most hunting

handgun ranges, especially in the heavy-for-caliber weights, but the premium bullets will truly allow the hunting revolver to shine. The Swift A-Frame, with its copper partition and front bonded core, gives fantastic terminal performance. With weight retention often above 85 percent — even at the high velocities associated with the speedy .454 Casull and bone-crushing .460 Smith & Wesson — the hollowpoint front core will expand to a diameter of just around 1.5x times caliber dimension. Barnes has also adapted their X-bullet technology,

resulting in their XPB handgun bullet. Being an all-copper, hollowpoint design, the XPB gives the terminal performance handgun hunters desire: good expansion, with the deep penetration associated with the monometal bullets.

It’s time for a detailed look into the terminal performance of different bullet types. When we’re done, don’t be surprised if you feel the need to rethink some old opinions — I know I did!

CHAPTER 15
SECTIONAL DENSITY, PENETRATION AND RETAINED WEIGHT

We first discussed sectional density, or SD in the interior ballistics section, but I firmly believe its most important function is in the terminal phase of the bullet's

flight. To briefly reiterate, sectional density is the ratio of the bullet's weight in pounds to the square of the diameter in inches.

SD=(Bullet weight in pounds)/Bullet diameter^2

The 150-grain Cutting Edge Raptor in the .300 Winchester Magnum.

This mathematical figure expresses only the weight and diameter of the bullet, not the shape or construction materials, so it’s a guide, but a useful one.

There is actually a debate raging that the above formula is incorrect for properly determining the actual SD of a bullet, and that the proper method for this figure should be as follows:


CZ 550 MAGNUM

The Cutting Edge Safari Raptor in .404 Jeffery.

$SD = (\text{Bullet weight in pounds})/(\pi \times \text{Radius}^2)$

I first came across the new equation in Pierre van der Walt’s *African Dangerous Game Cartridges* — a book you should definitely own — and while I completely agree with his reasons for the variance in our common method for deriving sectional density values, for this book I will adhere to the first method shown so

as to correlate my ideas to the published values throughout the industry.

Let’s compare and contrast some common .30 caliber bullets to get a feel for SD. Bullets in this caliber range from 100 to 250 grains on the extreme ends, but I’ve had much experience using 125-, 150-, 165-, 180- and 220-grain slugs in my .30 caliber cartridges.

125-grain .308 SD = 0.185

150-grain .308 SD = 0.226

165-grain .308 SD = 0.248

180-grain .308 SD = 0.271

220-grain .308 SD = 0.331

The petite 125 grain — which is available in some rather stout designs, should you choose to use them for lighter game — has an SD figure of .185, rather anemic when compared to the 180-grain's figure of 0.271, or the beefy 220-grainer with an SD of 0.331. The 165-grain bullet, often considered the best 'middle-of-the-road' choice for many of the medium-sized .30 caliber cases, has an SD of 0.248, so you can use that as a good basis for decision making. The SD figure, within the range of bullets for a given caliber, can be used to loosely

predict which projectiles within that range which will penetrate deepest (due to the additional length and weight) and which will give rapid expansion (due to the lower length/diameter ratio). Many Professional Hunters who pursue dangerous game prefer a bullet with an SD figure at or exceeding 0.300 to ensure deep penetration. In the .30-caliber bullets, that would be a projectile weighing 200 grains (SD 0.301); in .375 caliber, a 300-grain slug (SD 0.305); and in .416 caliber at least a 370-grain bullet (SD 0.305), while the popular 400-grain

bullets in that caliber give an SD figure of 0.330.

If you’re a varmint hunter, you’ll want bullets with a low SD figure to achieve the quick expansion that gives the hydraulic shock to deliver quick kills on the smaller animals. Deer hunters tend to stay in the middle — like the aforementioned 165-grain .308-inch bullet — to get a good blend of expansion (to generate shock, an effective tool when it comes to whitetail) and sufficient penetration (to reach those vital organs from any angle). Elk, bear

and moose hunters lean heavier, like the 180-grain in .308, as the size of the animal being hunted generally warrants a bit more bullet to plow through the additional bone and tissue.

These points have been the general standard for decades, and those SD figures could easily be interpolated for 7mm or .338 calibers, but there is a catch: the accepted figures were based on the experiences of 20th-century hunters, using (primarily) cup-and-core bullets. You need to take a look at the new construction methods and see how things

have changed — and I can guarantee you that things have changed.

I was turned onto Cutting Edge Bullets, a Pennsylvania company making lathe-turned all-copper hollowpoints. I was familiar with monometal bullets (Barnes has been around for years delivering the goods) but I hadn’t experienced the kind of consistency as delivered by Cutting Edge. My good pal Dave deMoulpied and I had used the Cutting Edge projectiles in a .416 Rigby and .404 Jeffery, respectively, in South Africa and Zimbabwe, and I wanted to

try them on plains game in my .300 Winchester Magnum. I was heading to the Limpopo Province with my wife Suzie to break the 11-year kudu curse. Now, a mature kudu bull isn’t all that much smaller than a bull elk, and while a .300 Winchester is a perfectly capable cartridge for both species, most hunters would choose a bullet of at least 165 grains, with the larger percentage opting for a 180- or 200-grain slug. Knowing the type of terminal performance the Cutting Edge bullets provide — the skived hollowpoint breaks into small blades

upon impact for severe impact trauma while the base remains at caliber dimension for deep penetration — I opted for the 150-grain Safari Raptor, leaning on bullet construction to hold things together for deep penetration, while taking advantage of the lighter bullet's flatter trajectory and lower recoil. The plan worked out just fine. I took several species on that safari, including a handsome 55-inch kudu bull, yet only managed to recover one of the Raptors. It was a going-away neck shot on the bull, which dropped him in his tracks, and the

base of the recovered bullet weighed 107.3 grains — not too shabby when you consider the polymer tip and the walls of the ogive are designed to break away. A Safari Raptor also accounted for a very nice waterbuck bull from about 220 yards, taking him cleanly through the heart. My Professional Hunter Nick Prinsloo was most amazed at the performance of the light-for-caliber bullet, and I may have made a convert of him.

The kudu curse breaker.

The Nosler Partition in .270 Winchester.

Today’s Barnes bullets are actually better than the original design, not an easy feat to accomplish.

So, how much bullet do you actually need? That’s a difficult question to answer. So-called traditionally established ideas on caliber/bullet weight are in desperate need of revision, and reexamination. John Nosler, the Godfather of premium bullets, experienced true bullet failure when the cup-and-core bullets (make unknown, but prior to his own designs) he delivered from a .300 Holland & Holland Magnum failed to penetrate the shoulder of a big bull moose. Were I forced to hunt an animal the size of a moose with a cup-

and-core bullet using that same .30-caliber rifle, I would consider 180 grains to be the minimum, and would be more comfortable with a 200-grain slug. However, I am absolutely certain that in a premium bullet, say a Swift A-Frame, Barnes TSX, or Cutting Edge Raptor, you could drop down to 165 grains and be confident that you’ll have your bull if you do your part. Even though the sectional density figure drops a bit, the construction of the bullet guarantees good penetration.

What’s the difference? The fact that the bullet won’t come apart, or prematurely expand. Most of the accepted recommendations are based on the fact that a cup-and-core bullet will expand and shed its weight to a certain degree. The hunters of my father’s and grandfather’s generation observed that the longer, heavier bullets performed better because they held together during the expansion/penetration phase. When Nosler developed the now-famous Partition — which uses two lead cores, separated by a copper partition to ensure

the rear core stays intact — he totally revolutionized the game. In fact, the Partition is still a great choice for any game smaller than elephant, and it's a bullet that I use often, especially for bear.

The Barnes X was probably the next huge leap in bullet technology, being a rather radical design which removed the lead core, resulting in a bullet made of all copper. Randy Brooks, who owns Barnes Bullets and is responsible for the design, created the first monomental hollowpoint that would expand upon impact and cause all sorts of damage to the vital organs of a

game animal, but removed the risk of bullet breakup. Being made of copper, which is less dense than lead, the monometal bullets are longer than the typical cup-and-core bullet of the same weight. The SD figure won’t change — it’s based on weight and diameter — but monometal bullets do have a different set of rules. Being longer they tend to take up a bit more room in the case (keeping the same Cartridge Overall Length), and their center of gravity moves a bit in comparison to a lead core bullet, but the terminal performance is wonderful.

Today’s Barnes bullets, such as the Triple Shock X and Tipped Triple Shock X, provide even better performance than did the original design; they’ve been revised to keep pressures lower and copper fouling to a minimum, while giving reliable expansion and all sorts of penetration. Weight retention is, more often than not, above 90 percent.

Chemically bonding the copper jacket to the lead core is another means of preventing premature bullet breakup. There are many bonded-core designs available today, and they are a fantastic

choice. They will often retain 85-90 percent of their original weight, indicating that the bullet has held together during its terminal phase. The Swift Scirocco and A-Frame, Hornady Interbond, Norma Oryx and Nosler Accubond are all good examples of this style of bullet. The bonding process slows down the expansion, yet holds things in place even with the tremendous impact pressures that the wicked-fast magnums of today can generate. A .300 Remington Ultra Magnum can push a 180-grain bullet over 3,300 fps without

issue, and that’s enough to test the mettle of any cup-and-core bullet. Imagine the destruction resulting from a shot less than 100 yards! Use a premium bullet and you’ll be much better served.

RETAINED WEIGHT

There is an ongoing debate that is as old as the hills: do you, as a hunter, want your bullet to completely pass through a game animal, or do you want it to remain against the offside skin, imparting all of its energy within the animal? My answer: It just depends.

Firstly, let’s not lose sight of the goal. As a hunter, you want to quickly dispatch your intended quarry, causing a quick, humane kill. It’s rather obvious that a pass-through shot will provide a better blood trail, should there be need to follow up a wounded animal, yet the ‘kinetic energy’ camp makes the case that all of the bullet’s energy should stay within the animal to cause the most shock damage possible. A bow-hunter wants the pass through; he or she is not depending on the energy shockwave to kill but rather upon traumatic hemorrhaging. As long as

your projectile does its job, quickly dispatching the animal, I’m OK with it.

There are, however, certain situations where a pass-through shot is undesirable. If you’re hunting a whitetail buck, which is slowly cruising through the woods looking for his paramour, a pass-through poses no issue. If (like me) you live to pursue the Cape buffalo, which is primarily a herd animal, a pass-through can pose an issue: the gun you’ll be using (.375 H&H or bigger) has the power to completely pass through a bull buff, wounding or killing an animal behind

him. That’s a tricky situation. You need enough velocity and bullet weight to properly wreck his vitals, but not so much that a pass through is a guarantee. This is one area where the Swift A-Frame’s qualities shine. Such a bullet expands enough to slow things down once inside the game, retains enough weight (usually 90 percent plus) to properly penetrate, yet is often found just against the offside skin. I recovered both of my shots from my Zambian bull, and you could feel them lying right against

the offside shoulder. Perfect job, in my opinion.

Secondly, I have customers tell me on a regular basis that certain bullets have ‘failed.’ When I ask them to describe their situation, most stories involve a bullet retrieved from the animal during a post-mortem examination that weighs very little when compared to its original weight. I then set the hook: “You recovered the bullet from the animal, which was dead, right?”

“Well, yes.”

“Did you need to shoot the animal again?”

“Well, no. I tracked it up and found it dead.”

“I don’t think the bullet failed, it just didn’t give the results you expected.”

“But I wanted my deer to drop in its tracks.”

“We all do.”

Terminal ballistics are a funny thing. Two shots at the same relative distance, using the same bullet and cartridge, will drop one animal as if the hand of God came down from the heavens, yet the

second animal will need to be tracked for some distance. Why is that? Assuming that both shots were properly placed into the vitals, why would one fall and one run? There are great debates about the physical reasons that an animal falls or runs, theories that include hitting the heart at the instant a particular chamber is filled with blood (think about shooting a milk jug filled with water), or empty (much less dramatic). In my experience, which covers about two dozen big game species at the time of this writing, a bullet has only ‘failed’ when it does not kill a

game animal within a reasonable distance and time from a properly placed shot. That can happen either from premature breakup or a failure to penetrate and destroy the vital organs. There are certain tools for certain jobs, and I like to hedge my bets by using what may be more bullet than necessary. In today’s world, bullet choice has almost superseded cartridge choice.

I try to recover bullets from game animals, and keep notes and form opinions based upon real-world situations rather than depending upon theoretical

data; though it’s a long road and requires a whole bunch of time and dedication, not to mention the fact that bullets and animals don’t always do what you’d like them to do. My grandfather had a favorite phrase: “You don’t live long enough to make all the mistakes on your own, so learn from other people’s mistakes.” He was right.

What do you want your chosen bullet to look like, were you to recover it from your chosen game animal? Do you prefer a wide mushroom, and say 50-60 percent weight retention, knowing that the vitals

were destroyed (my ideal deer bullet)? Or do you subscribe to the “swatting a fly with a sledgehammer” theory like I often do for larger species, choosing a bullet more than tough enough that’ll retain nearly all of its weight, but might be unrecoverable? That decision is ultimately up to you. Let’s take a look at which types of bullets fall into these categories, so you can make a better decision for your hunting situation.

The Nosler Partition in cross section after impact.

The 220-grain Hornady InterLock offers plenty of sectional density.

CUP-AND-CORE BULLETS

The cup-and-core bullets, like Sierra's GameKing and ProHunter, Hornady's Interlock, Remington's Core-Lokt and similar open up quickly to impart shock and ruin vital tissue. These bullets come in many shapes and sizes, and their performance is what helped form the opinions of many early gun writers. Using our .30 caliber example, a 150-grain bullet would certainly make a good deer and pronghorn bullet, but may not make a wise choice for elk or moose; there simply isn't enough bullet length (sectional density) to allow for the weight

lost during impact. Now, that's not to say that the bullet won't eventually kill an animal the size of an elk, but it may be due to a superficial wound, or from infection; it'll be difficult to recover an animal shot in that manner. Hence the recommendations of heavy-for-caliber bullets, and Elmer Keith's love of heavy bore rifles. The same theory of high SD bullets can be applied to the lighter bores when used for big game. The classics, like the 7x57mm Mauser, 6.5x54 Mannlicher-Schoenauer, and 6.5x55 Swedish Mauser made their reputations

on larger game by using long, heavy, round-nosed bullets. The 6.5mm 160-grain (SD 0.328) and the 173-grain 7mm bullet (SD 0.310) worked just perfectly on deer-sized game, as well as some of the African antelope that equal the weight of an elk or moose. Blayney Percival, a Professional Hunter and Game Ranger in Kenya in the early 20th century preferred the light 6.5x54 for his work; he even used it for rogue lions.

However, impact velocity can be the undoing of the cup-and-core bullet, as Elmer Keith found out early on. Keith

preferred the heavier bullets mainly because he knew they would get the job done. It was mainly due to wildcat cartridges he'd developed like the .333 OKH that the .338 Winchester Magnum became a staple of elk hunters. A .338-inch 250-grain bullet (SD 0.313), driven to a muzzle velocity of about 2,650 fps will certainly take any elk, moose or bear that ever lived, but it is not the requirement, even with some of the thicker jacketed cup-and-core bullets. But, in Keith's day, it gave him more confidence than would the lighter 130-

grain .270 bullets promoted by contemporaries like Jack O’Connor. When it comes to a traditional bullet, I lean more toward Keith than O’Connor on that question, especially when I’m using a magnum cartridge.

When shooting a .308 Winchester or 7x57 Mauser, impact velocities are one thing, but bump those cartridges up to a .300 Weatherby or 7mm Remington Magnum and things get very interesting. Simply increasing the muzzle velocity — and theoretically the impact velocity — by 400 fps or so will definitely stress the

best of the cup-and-core bullets. The Hornady Interlock and Remington Core-Lokt use a cannelure to help keep things together, but very few of the Sierra bullets employ this feature. Perusing the Sierra catalog, you’ll find some bullets have thicker jackets than others. For instance, the .308 165-grain GameKing hollowpoint boat tail was designed to shoot like its MatchKing counterpart, but features a thicker-than-normal jacket, one that will stand up to magnum impact velocities. I’ve used this bullet for years, in both a .308 Winchester and .300

Winchester Magnum, and it’s served me very well. I’d be completely confident choosing this for a black bear bullet, or even for elk. Hawk Bullets, hailing from New Jersey, is a semi-custom bullet shop that allows you to choose the jacket thickness for the job at hand. I really like that option, especially for some of the more obscure calibers, like my .318 Westley Richards.

Customizable 200-grain Hawk Bullets for the .318 Westley Richards.

The Hornady ELD-X is a great long-range hunting bullet.

There have been attempts at marketing a cup-and-core delayed-expansion bullet.

Winchester’s original Silver Tip used an aluminum cap on the meplat of the bullet to prevent premature expansion, and the thing worked. I still have a handful that my dad bought me for bear hunting with my .30-30 WCF. They worked well for deer, too, but I still haven’t happened across a bear while carrying them. The Remington Bronze Point was designed with a bronze tip — more to prevent meplat deformation than for controlled expansion, I believe — but I would venture to say that it did help to control violent expansion a bit.

The original Speer Grand Slam bullet used a lead core of different hardness to ensure proper penetration. And while that bullet is not nearly as popular as it once was, it still performs wonderfully. I’ve loaded it for clients headed on bear hunts, and it’s worked just fine on big bruin, whether bayed by hounds or over bait.

The polymer tipped cup-and-core bullets work much like a hollowpoint, with the exception of having the tip that not only increases the ballistic coefficient, but also acts as a wedge to forcefully open the point for positive

expansion. Nosler's Ballistic Tip and the Hornady SST are good examples. And like others of sufficient weight and length, these work well as a big game bullet. So, it's apparent that some examination and planning is warranted when choosing a cup-and-core bullet so you end up with the proper balance of expansion, penetration and retained weight.

BONDED CORE BULLETS

Bonded core bullets are a different story altogether; they simply hold together under stress, yet many of them

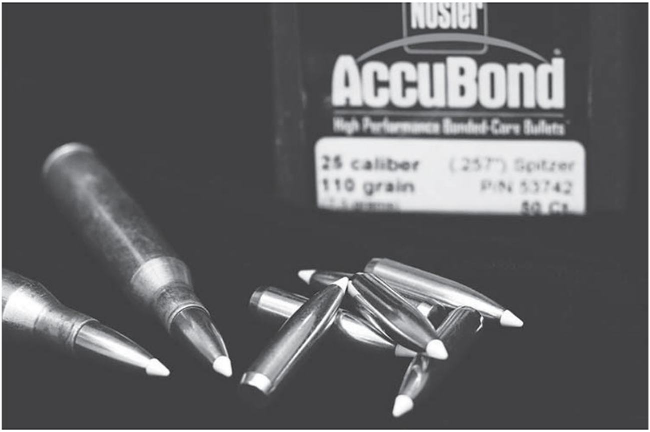
will maintain a profile like the best of the cup-and-core designs. The highly popular boat tail/polymer tip combination is well represented in the bonded core lineup of projectiles, providing an excellent long range combination for the larger, tougher animals. Bullets like the Nosler AccuBond, which pays homage to the Ballistic Tip profile, and the AccuBond Long Range, which provides an even higher ballistic coefficient, greedily hold onto as much of the velocity generated as possible during flight to deliver it onto the animal, thus the terminal qualities of

these bullets are excellent. The process of chemically bonding the lead core to the copper jacket allows for much more retained weight, as well as better penetration. Nosler has made this bullet a bit softer up front than some other designs to initiate expansion even at lower impact velocities (longer range shots), yet the rear portion stays intact to drive through the vitals. The Swift Scirocco II is another bullet utilizing the polymer tip/boat tail combo, but features a very thick jacket toward the base. As mentioned previously, I’ve come to love

this bullet for a number of reasons: it’s accurate, bullet-to-bullet tolerances are very tight (when I weigh them on a scale they are usually within ½ grain of the listed weight) and they hit very hard. I’ve personally used the bullet on a thick-bodied bear, and on whitetails. I’ve loaded the bullet for clients for their elk and moose hunts; all have been successful. My bear was taken at less than 50 yards, and I gave him two shots, both passed through. It was a 180-grain bullet from my .308 Winchester (muzzle velocity of 2,525 fps) so it wasn’t exactly

screaming-fast, but it’s a testament to the Scirocco’s strength that both shots were pass throughs. The bear didn’t go more than 15 yards. The one Scirocco that a client did recover from his elk weighed in at 162.5 grains, for a weight retention of 90 percent; that was delivered from a .300 Remington Ultra Magnum at 85 yards with a muzzle velocity of 3,360 fps. I think you can see why I’m a huge fan of this bullet; it delivers the goods in all sorts of calibers, from 6mm up to .338, and does it with authority. When I’m looking for a bullet that best combines

the long-range capabilities of a high BC design, and the penetrative qualities needed for reaching the vitals reliably, I generally reach for either the Nosler AccuBond or the Swift Scirocco II.



The Nosler AccuBond, shown here in the .25-06 Remington.

The Swift Scirocco II is an excellent choice for high impact velocities.

Hornady’s Interbond is another similar design, with the tell-tale red tip, and delivers a similar performance. Hornady loads this bullet in their Superformance

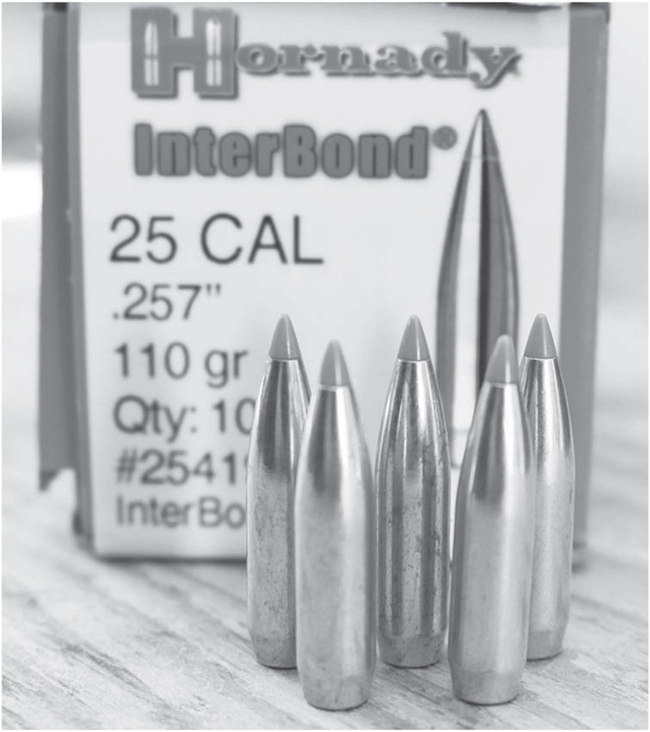
line of ammunition, making for a great high velocity/strong bullet combination. I’ve not personally hunted with it, but I’ve loaded it for a number of clients, who’ve all had good results.

All of these bullets yield a similar level of performance, expanding roughly 2.5 times their original caliber in diameter, and the high weight retention that is indicative of good terminal performance, even if bones are struck. I like this style of bullet for an all-around choice. It performs well on close shots, yet is configured to retain energy downrange

and give the best blend of terminal performance across a wide spectrum of hunting situations.

There are other bonded core choices, though, and depending on your style of hunting these may serve you better. I'm referring to the semi-spitzer bonded core bullets, which perhaps don't have the high BC figures of the boat tails, but definitely make up the difference by hitting a bit harder. It's a difficult phenomenon to explain, but I've noticed that a semi-spitzer or round nose bullet seems to make an animal 'shudder' when

hit, and you can actually see a difference once you connect. Such bullets in a bonded core configuration are among my favorites for hunting situations where I’m hunting truly big game with shots inside of 300 yards. Among these designs, I can name three favorites that will absolutely give great penetration, and reliable expansion.



Hornady’s InterBond. The bonding process slows down expansion.

The Swift A-Frame.

The Swift A-Frame was, until recently, the only bullet I'd used in Africa, for my first three safaris. With that bullet in three different cartridges I've cleanly taken animals from the size of the diminutive steenbok up to and including eland and Cape buffalo. It's very similar to the Nosler Partition in that it uses two lead cores separated by a wall of copper. The front core is bonded to the thick jacket to prevent premature expansion. The classic form of the recovered A-Frame is a good mushroom up front at twice caliber dimension, and a 'riveting' of the shank

just behind that wall of copper, with a weight retention well into the 90 percentile range. I’ve often described this bullet as ‘meat-resistant,’ in that the bigger the animal you hit, the more it will open — actually improving chances of recovery. When you hit the smaller animals with an A-Frame, it tends to pass through. The A-Frame is a classic example of a strong bullet with which you can confidently drop down a bit in bullet weight/sectional density, yet still be confident that you’ll reach the vitals. It opens up reliably, and I’ve used it on

some long shots, out where things slow down, still with positive results. For example, take that eland hunt I mentioned when discussing the effects of wind drift. While it was difficult enough to just make that shot, I was concerned about expansion. That 300-grain A-Frame at that muzzle velocity out at 400 yards would slow down to somewhere around 1,650 fps — not exactly optimum for an antelope weighing between 1,800 and 2,000 pounds — but when I heard the ‘thunk’ of the bullet connecting, I could clearly see I had nothing to worry about. I

didn’t recover the bullet from the follow-up shot, but we did find the first one. It weighed 287.4 grains, for 95.8 percent weight retention. That’s why I love that bullet so much. Swift makes it in calibers from .25 caliber up to the big .500s, like the .505 Gibbs and .500 Jeffery. Also, the bullet is golden in a cartridge that may be considered marginal, like using the 6.5-284 Norma for elk; load it with a good 140-grain A-Frame, and you’re good to go.

Author with bushbuck, taken with 400-grain A-Frame in .416 Remington Magnum.

North Fork semi-spitzers yield incredible terminal performance.

The 175-grain North Fork, recovered from a frontal shot on a whitetail deer.

The North Fork semi-spitzer is another bullet that yields incredible terminal performance. Constructed of a pure

copper jacket chemically bonded to a lead core — the core sits in the forward two-thirds of the bullet — it has small grooves in the shank of the bullet to keep pressures nice and low. The bullet is designed to keep weight forward, by using a lead core that sits forward, and the semi-spitzer profile. The North Fork soft point delivers full, straight-line penetration; in other words, the bullet likes to pass clear through. The folks at North Fork explained it to me like this: “Imagine a rear-wheel drive car in the snow: when resistance is met, the rear of

the car tends to push out to one side or the other. A front-wheel drive will tend to pull itself through the resistance. And that’s the concept behind our bullets — their weight-forward design greatly aids in deep penetration, and here in Oregon we appreciate the exit wound for a larger blood-trail.” My experience with this bullet is that it performs exactly as designed and the only one I’ve been able to recover was a 175-grain 7mm slug from a 7x57 Mauser that was a straight-on shot. I’ve become a huge fan of it. Penetration is never an issue.

The Norma Oryx is a great little bullet, which is sort of a hybrid design to provide a good balance of expansion and penetration. It’s a copper-jacketed, semi-spitzer with a lead core, but the rear shank of the bullet has the jacket chemically bonded to the core. Upon impact, the nose section opens like a conventional bullet creating a classic mushroom, yet the bonding process at its base prevents it from coming apart, keeps it driving through the vitals. I’ve had nothing but positive experiences with the Oryx. In fact, my 6.5-284 Norma drove a

156-grainer through a big-bodied eight-point whitetail for the most dramatic one-shot kill I’ve ever had. At the shot, he flipped over onto his back, legs fully extended like an upside down table, and stayed there in that position. I only wish I could’ve recovered the bullet for observation, but it gave a complete pass-through. However, I’ll take those results every time. If you’re looking for “just a bit more” than what a conventional bullet has to offer, I’d highly recommend the Oryx, especially if shot distances are within 200 yards.


norma USA
~ PRECISION AMMUNITION ~
6,5-284
156 gr Oryx
20166062
WWW.NORMA-USA.COM
7 393923 304786

The 156-grain Norma Oryx.

MONOMETAL BULLETS

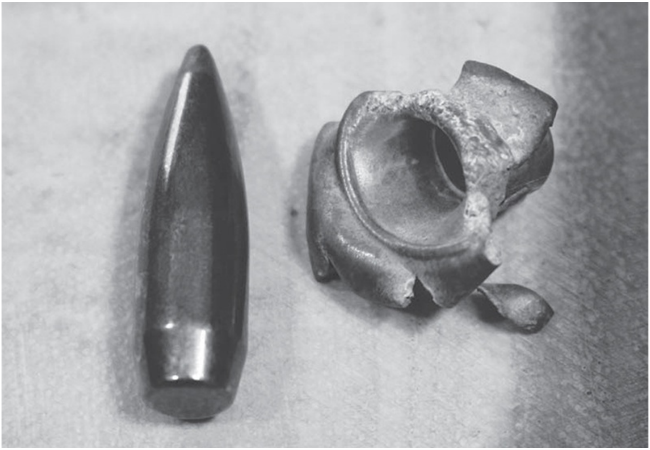
Monometal expanding bullet construction is a fantastic method of preventing premature breakup. The Barnes X bullet was nothing short of revolutionary, in the fact that it had no lead core whatsoever. The all-copper design did pose some issues though, like increased copper fouling, and the fact that the bullets were longer than their lead core counterparts and took up a bit more room in the case, but Lord! — did they penetrate. The newer TSX and TTSX

designs eliminated a good portion of the copper fouling issue, and penetrate like gangbusters. I can honestly say that with a bullet of this style (the Hornady GMX, Federal Trophy Copper and Nosler E-Tip can certainly be included in this bunch) you’ll be able to get away with a bit less sectional density to achieve the same terminal effect. I used a little .243 Winchester in a Savage Lightweight Hunter with an 85-grain Trophy Copper to absolutely crumple a Texas buck; it was a 125-yard shot, and one of those few instances where the animal literally

fell in his tracks. Oddly, the bullet hit a rib, and turned 90 degrees upward, to smash into his spine — hence the instant drop — but everything in the bullet’s pathway was destroyed.

The small eight-point buck that received the death blow from the 6.5-284 Norma and an Oryx bullet.

The little Savage .243 Winchester dropped this tall-racked seven-pointer in his tracks.



Cup-and-core boat tail bullets can separate upon impact.

BULLET DISADVANTAGES

Now, cup-and-core bullets — which I don't want you to think I dislike, it's just that I have come to appreciate the

benefits of the premiums in the penetration department — come with their own set of issues. Many of my rifles have excellent accuracy with spitzer boat tail bullets of traditional design. However, I've found these bullets have a tendency to shed their copper jackets, especially when impact velocities are on the higher side of the spectrum. That is why I've traditionally used the higher SD bullets, especially in magnum cartridges. I also believe that this idea had an undeniable influence on the Elmer Keith/Jack O'Connor arguments that set

the benchmarks for our established minimum cartridges on particular sizes of game animals.

RETAINED SECTIONAL DENSITY

If the radically expanded bullet doesn’t penetrate as well as a bullet which stays closer to original caliber diameter, and a bullet that doesn’t expand much fails to destroy enough tissue, how should you balance penetration with expansion? I mean, if penetration were the key, we’d all shoot the solids used by African buffalo and elephant hunters. And if

expansion alone did the trick every time, we’d all be shooting varmint-style bullets with low SD figures and thin jackets, right? There has to be a balance, and it will take some research to figure out what will work for you.

The idea of retained sectional density correlates retained weight to expanded diameter. Again, sectional density is the ratio of bullet diameter to bullet weight. If you expand the bullet’s diameter (as it does after impact) and retain 100 percent of its weight, you will obviously lower the SD figure. If you shed bullet weight

(again, that happens more often than not) you will further lower the SD figure. So, there needs to be a balance between the two, especially when the game size exceeds that of the common deer species.

THE SWIFT A-FRAME

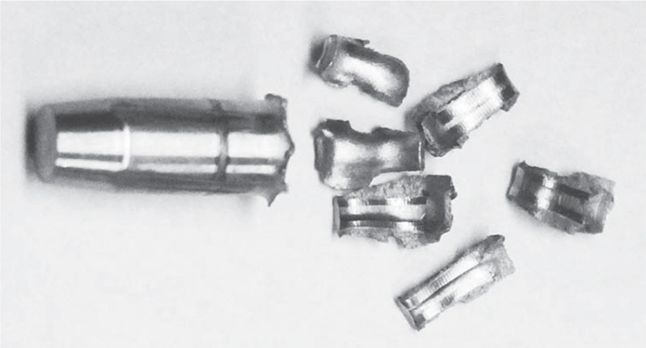
I have probably taken more species of game with a Swift A-Frame than any other bullet. I've used it all over Africa and North America, with nothing less than stellar results. I've used it in calibers from 6.5mm to .308 to .375 and .416, and it's been an accurate bullet in all of my rifles. Again, the A-Frame is a partitioned

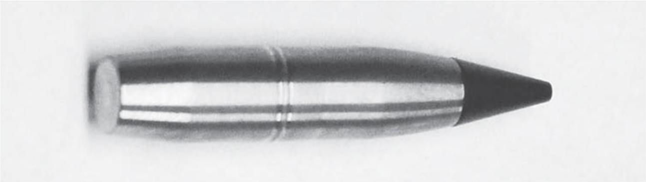
bullet, with a thick jacket, and the front core is chemically bonded to that jacket. It is a semi-spitzer profile with a flat base. While the BC figures are better than the hemispherical round-nosed bullets and flat points, the A-Frame doesn’t hold a candle to the sleek, spitzer boat tail bullets that are associated with true long-range work. However, it does make a good choice for safari where shots rarely exceed 250 yards, as well as North American hunts at similar ranges. The A-Frames that I’ve recovered have a similar, signature shape: the front core is

expanded to right around 2 times the caliber dimension, and there is a bulge, or rivet just behind the partition. Many of the A-Frame bullets I’ve recovered have retained over 90 percent of their weight.

Let’s look at what happens to the bullet once it expands. Assuming a 180-grain bullet weight, in .308 caliber, that’s a sectional density figure of 0.271, and upon expansion to twice diameter reduces that figure to 0.068. Using the formula for sectional density: 180 grains converted to pounds = 0.0257; divided by the square of 0.616 (the twice expanded

diameter) yields a figure of 0.068, rather bleak in comparison to the original figure. But, that expanded bullet does all sorts of damage on the way to its resting place, and a .616-inch hole is much bigger than a .308-inch hole.





Cutting Edge Bullet’s Raptor is a revolutionary design. It works very well in a variety of situations.

THE CUTTING EDGE RAPTOR

Here’s another bullet I’ve come to love in a wide variety of calibers. Cutting Edge makes the Raptor in a 150-grain configuration, and it has worked very well in the field. Its nose or ogive section breaks into small blades upon impact, delivering the impact trauma we hunters love, while the base of the all-copper bullet remains at caliber dimension. It starts out with a SD figure of 0.226, much less than the 180-grainer’s 0.271. My own recovered bullet, taken from a

large kudu bull in South Africa, weighed 107.3 grains — 71.5 percent weight retention — but stayed at exact caliber dimension. At this retained weight, the base has a ‘retained’ SD of 0.162, explaining why the base of the lighter bullet will often completely penetrate a large game animal, even on a frontal shot.

This illustrates how and why the terminal performance of different types of bullets can and will vary, especially with some of the newer designs. Unlike the traditional cup-and-core designs that we’ve come to know so well, and learned

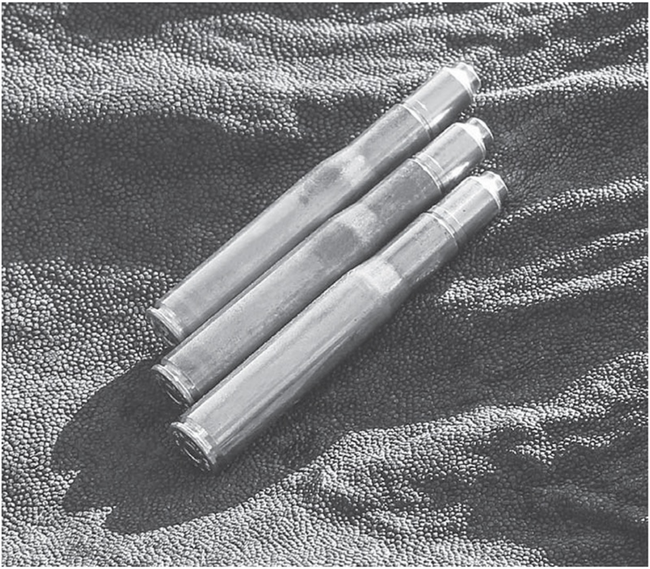
so much about from the classic gun writers, these new bullets — only two of which I’ve given example — will take some getting used to and require additional experimentation to fully prove in the game fields. So far, though, the results are pretty hard to argue with.

THE WOODLEIGH HYDROSTATICALLY STABILIZED SOLID

However, there is one more bullet that takes things even further: the Woodleigh Hydrostatically Stabilized Solid. This

concept is way out of left field, but I’ll be damned if it doesn’t work well. The bullet, developed by the Australian firm of Woodleigh Bullets, is a monometal solid, designed to give zero expansion, destroy the vital organs and tissues, and all the penetration anyone would want. The solid has a small cup at the front of the bullet, which uses the concept of cavitation to destroy the blood-rich tissues of the vital organs. Upon impact, the cup at the meplat creates an air bubble in front of the bullet, helping to keep it in a straight line as it penetrates

through the game rupturing blood vessels in an 8 to 12-inch cylinder around the path of the bullet.



The Woodleigh Hydrostatically Stabilized Solid, on the ear of the bull elephant it dispatched so neatly.

An impala ram which fell immediately to the Woodleigh Hydro.

I’ve had the opportunity to use this bullet on a variety of game, varying in size from impala (a bit smaller than our

whitetail deer) to blue wildebeest (slightly smaller than our elk, but no less tenacious) up to and including the African elephant. I have yet to recover one of these bullets, and all the animals went down very quickly. The Hydro kills by rupturing and destroying the cell walls of the tissue within that cylinder of destruction. Not to be gross, but my elephant’s lungs were simply jellified by two lung shots, as was the upper portion of the heart. Heart/lung shots on an animal the size of an African elephant are not like a deer or elk; there is simply no

way to generate enough shock to put an animal this big down. You’d need a 155mm Howitzer, and even then it would be questionable. However, with two Professional Hunters standing beside me slack-jawed over a bullet that nearly put the great beast down on his haunches with the first shot was rather interesting. There was doubt in both their eyes at the start of the safari, looking at these strangely configured projectiles, but with two quick shots from my .404 Jeffery, I had converts instead of doubters. I believe this bullet will be the wave of the

future. It’s available in calibers from 7mm up to and including the behemoth .577, and could really change the game. Imagine a good .30-caliber Hydro, in a .30-06, fully capable of taking a grizzly bear, because you’ve got the consummate blend of tissue destruction and deep penetration. Or what about the capabilities of the .338 Winchester Magnum with a 225-grain Hydro! It’d require some testing, but I believe you’d take Cape buffalo with that combination. There certainly are good things to come with the Woodleigh Hydro, and based

upon the way my Heym .404 Jeffery shoots this bullet, it won’t be the last time I use it. Federal Premium wisely includes it in their lineup, so it’s not just a component bullet for reloaders. If you’re headed after dangerous game, give this bullet a whirl.

PENETRATIVE QUALITIES OF MODERN BULLETS

What makes for good penetration? Why will one bullet penetrate while another won’t? What qualities are desirable to achieve the necessary penetration for a quick kill?

As we discussed above, with a cup-and-core bullet, high impact velocities will definitely test the integrity of the classic design. To combat this, companies have used thicker copper jackets to slow the expansion of lead core bullets. An example is the Sierra GameKing hollowpoint, which has a very thick jacket and, even though it’s a hollowpoint — a bullet style normally associated with frangibility and rapid expansion — it will definitely stand up to magnum impact velocities. I use it in my .300 Winchester Magnum and 6.5-284 Norma, with good

results. Some boutique bullet companies offer a variety of jacket thicknesses (such as Hawk Bullets from New Jersey) so you can tailor the bullet to the job. Deer hunter? A thinner jacket will work for you. Bear/elk/moose on the menu? A thicker jacket and perhaps more weight (equaling more length) would make a wise choice.

However, does the conformation matter? Does one nose profile give better penetrative qualities than another? Yes, it does matter. And there are some choices that are better than others.

In my experience, there is a big difference in visual impact between round-nosed and flat-nosed bullets, and the spitzers. That’s not to say that the spitzers are in any way bad, but a round-nosed bullet will make an animal ‘shudder’ when hit, imparting energy better. But, we’ve also seen via the wind and trajectory values that the round-nose bullets are inferior at longer distances. So therein lays the dichotomy, at least in my mind. I love the long-range ballistics of the spitzer boat tails, but I really adore the terminal ballistics of the flat- and

round-nose bullets. Generally speaking, when the game is large and the distances are short, I prefer to take advantage of the penetrative qualities of the less-than-sleek profile bullets, yet when I know I’m after thin-skinned quarry, or on a hunt where the distances may exceed 200 yards, I prefer spitzers. If I have a hunt where I can’t exactly determine what shot I’ll have, spitzers again get the nod, hedging my bets in the event of a long shot, and depending on the size of the game, may be a bonded core bullet.

There are situations where penetration is paramount. Perhaps a game animal has the potential to rip, bite, claw or stomp you to pieces. Hunting dangerous game animals is a totally different experience. While I’m not an adrenaline junkie (I have an incurable fear of heights, as well as flying) I do love the thrill of dangerous game, and the adventures in the wild places that are still left on earth. In my opinion, you owe it not only to the game animal, but to your family, to see that the animal is dispatched quickly and cleanly, and that you and your hunting party

return unharmed. You therefore need a

rifle/bullet combination that will get the job done.

I have friends and colleagues that have used traditional cup-and-core spitzer bullets to take Cape buffalo and huge grizzly bear; the trophies are on the wall and no one was harmed. I also have heard tales of poor penetration, premature bullet breakup, and other terminal ballistic woes. Let’s back up for a minute and reexamine the whole process. Death is caused by severe tissue trauma and blood loss — unless it’s a brain shot, where the plug is pulled — and for

millennia the bow and arrow has accounted for some of the nastiest beasts on the planet. Modern archers take big game including elephant each year with high-tech compound bows and arrows tipped with the strongest of broadheads. But, though death will invariably ensue for an animal with its vital tissue destroyed, what happens in that period of time between the wounding of that animal and its death can be catastrophic to the hunting party. It can be bad for your health. A grizzly can maul you in a matter of seconds. A heart-shot elephant

can close in on you in the blink of an eye. Point here is, there are proper tools for the job, and when it comes to dangerous game, you want the best you can get.

Reading some of the classic ballistics books that relate the terminal capabilities of our centerfire cartridges, like John Taylor's *African Rifle and Cartridges*, you can get a feel for why some ballistic formulae have the reputation they do, but there are some misconceptions that need to be addressed. Remember, any sectional density figure is a simple ratio of mass to diameter, and doesn't take into account

the bullet's shape or structural integrity at all. With that in mind, the generalizations regarding the relationship between SD and penetration must be taken with a grain of salt. For example, comparing two 180-grain .30 caliber bullets, each will have an SD figure of 0.271; yet if one were a pure lead cast bullet and the other an all-copper solid, you could easily imagine the difference in penetrative qualities. Should the shoulder bones of an elk be struck, that pure lead bullet would quickly deform, and penetration would invariably be poor. Yet, the modern

monometal solid would whistle on through, without any expansion. So, SD does play a role in penetration, but it’s only one part of the equation.

We’ve looked at the various construction methods, getting an idea of why modern bullets perform the way they do, but we must also look at how the nose profile of a bullet affects the penetration path. Going back to the North Fork concept of keeping the bullet’s weight forward for straight-line penetration, you’ll find that African Professional Hunters tend to prefer a round-nose or

flat meplat bullet, as such facilitates straight-line penetration. Why would this profile work better than a spitzer?

The Original Barnes X designs came with mixed reviews from the field.

Federal's Trophy Bonded Bear Claw.

First of all, bullets are fired at a rotational rate that is optimized for the atmosphere (air), not for hide, tissue and bone. As the bullet contacts an animal,

the rotation must be affected, as the medium has become considerably thicker. Striking nose-first, the bullet’s rotation is upset. Depending on where the center of gravity is, the bullet may do some funny things. Going back to Pierre van der Walt’s *African Dangerous Game Cartridges*, testing proved that a non-expanding spitzer bullet will tend to flip directions, and exit with the rear of the bullet facing forward. Just like the example of a rear-wheel drive vehicle in snow, the rearward center of gravity combined with the resistance of the

newly introduced medium (flesh and bone) causes the bullet to veer off of its course, with the nose deflecting in some direction. Van der Walt demonstrates this concept well, confirming that a flat- or round-nosed projectile will tend to hold its direction and alignment. This idea makes an awful lot of sense, and lends credence to the oft-repeated concept that the military 5.56mm NATO bullet will ‘tumble’ or bounce around within the human body. It is more likely that the full metal jacket bullet skews once resistance is met, actually exiting rear-end first. I’ve

had monometal copper bullets do the same thing. I told you of that buck in Texas which I'd hit with the little .243 Winchester using an 85-grain Federal Trophy Copper bullet. Why would a bullet heading at a slight downhill angle decide to change course at right angles and smash into the spine? I suspect it hit a rib and was deflected by bone, but I also think the deflection may have been enhanced by a rearward center of gravity and high impact velocity as the shot was only 125 yards.

The early Barnes X bullets suffered from this same phenomenon; many field reports indicated that the entry and exit wounds were at caliber dimension, indicating little, if any, expansion. In other words, the bullets were behaving like solids. While the penetration was fantastic, the resulting trauma was minimal in comparison to what the bullet could do when it opened. The thinking was that the hollowpoint was getting pinched in the denser medium of flesh and bone, and expansion was nullified; I’d also be willing to wager that the

bullets were exiting rearward, as the long-for-weight copper design combined with a hollowpoint spitzer profile moved the center of gravity rearward. Regarding the expansion problem, Barnes has since corrected the issue. Today’s TSX and TTSX are among the finest bullets available, but it gives you an idea of what can happen with a long spitzer in the water-rich medium of flesh.

Once a bullet begins to expand, its center of gravity shifts, and the sectional density changes. The mushrooming effect slows the velocity while destroying tissue

along the way. Too little mushrooming, and your bullet will behave like a solid, too much and it stops before it can effectively ruin sufficient tissue. Compound that with the fact that tissue is a flexible medium, and that a wound channel will expand and contract, and you’ll understand why the hunters of yesteryear were fans of bigger bore diameters: the bigger the hole, the more trauma would be induced. Lower velocity round-nosed bullets helped to keep penetration in a straight line. The classic ‘full patch’ or ‘solid’ bullet was one way

to guarantee that a bullet would give adequate penetration on the African heavyweights, and for years the Professional Hunters who were guiding for Cape buffalo recommended them exclusively. Penetration was paramount. Elephant hunters needed the best penetrating bullets they could get; the skin at the shoulder can be well over an inch thick, and a frontal brain shot requires getting that bullet through 18-20 inches of honeycombed bone. Even today, almost all of the bullets that get that job done best are round-nosed or flat-

nosed, giving a clear idea of how important the nose profile can be when it comes to penetration.

This is counterproductive though when it comes to sending that same projectile over long distances through the air. African hunting is predominately done at close range, with a 250-yard shot being on the long side. In the terminal phase, lower BC profiles are preferred to the aerodynamic shapes better suited to long-range shots.

This is why companies push the envelope when it comes to bullet

development, and abandon traditional ideas. Jack Carter’s Trophy Bonded Bear Claw is not a new design, but it is a fantastic one. Using a smaller lead core located at the front of the bullet, and a rear section of all copper, the Bear Claw keeps its weight forward, yet maintains a spitzer design. The solid copper shank behind that lead core stays intact to ensure good penetration, yet the nose is soft enough to give good expansion. The Bear Claw is currently loaded in the Federal Premium line, and I am a huge fan of the bullet for all kinds of hunting.

But there are newer kids on the block, who are fully embracing their own respective schools of thought.

One of these companies is Peregrine Bullets, from South Africa. Another is the aforementioned Cutting Edge Bullets. Both have radical designs that deviate from the cup-and-core principal and take the monometal concept to new heights.

Peregrine has embraced both schools of thought, offering fantastic monometal bullets in a couple different configurations. Their engineers recognize not only the need for a monometal

projectile that opens reliably and regularly, but see the difference between the camps who prefer the flat, “bush” meplat and those looking for a sleek spitzer bullet for longer shots. I’ve loaded and used both styles of bullets, and they are fantastic. Let’s look at the “bush” bullets first.

The Peregrine VRG3.

The Peregrine BushMaster VRG-3 is a dichotomy in the eyes of most ballistic engineers. It’s a flat meplat bullet, constructed of copper (the very grain structure of which has been manipulated

and designed for optimum performance), yet features a boat tail for an increased BC figure. In addition, its hollowpoint cavity is filled with a brass insert that sits flush with the nose. A cavity of air is left below the brass insert, acting like a plunger to initiate expansion. Since air is difficult to compress — more so than metal — once the brass plunger meets resistance it will be forced to move rearward. The air pocket resists compression, forcing the sidewalls of the bullet outward in a radial fashion. The combination of a larger wound channel

from the flat meplat and the forced expansion causing tissue damage results in a bullet capable of awesome terminal ballistics. The construction methods ensure highly uniform tolerances, and the accuracy of the bullets reflect that. I’ve loaded the VRG-3s in Dave deMoulpied’s .416 Rigby, and have seen him print ¾-inch groups. They perform much the same in my .404 Jeffery, and in the new Heym Model 89 in .450/400 3-inch NE double rifle. Such bullets solve the problem of reliable expansion and wound channel size when it comes to a

monometal, and at the same time give the huge energy transfer for which round- and flat-nosed bullets are famous. VRG-3s are an excellent choice for buffalo hunters, and work perfectly on the larger plains game species like kudu and eland. I am privileged to call Kristof Aucamp, the Public Relations manager for Peregrine a personal friend. We’ve spent a considerable amount of time discussing these designs. I inquired about the origins of the plunger concept and how it affected the terminal ballistics.

“This is the brainchild of Adriaan Rall, who was the creator of the plunger and cavity concept for Peregrine copper bullets,” Aucamp revealed. “The cavity has multiple functions. First, it acts as a shock absorber if the bullet hits bone very soon after entering the skin, thus contributing to the conservation of retained weight of the bullet. In other words, it helps to keep the formation of the mushroom intact and inhibit the shedding of weight in the form of petals or broken off copper pieces. In effect, it also helps to maintain straight-line

penetration whenever the plunger is able to conserve and control the mushroom formation. This is vitally important when hunting tough and dangerous animals. Of course, there never is a guarantee that the mushroom will be perfect after hitting bone in big animals, but we found that the cavity in the plunger design is a big plus, more so with the big bore calibers. The air cavity also assists with the controlled expansion of the bullet in three stages.”

So, the design keeps the bullet intact for straight-line penetration, yet handles

the tough shoulder bones of dangerous game? I’m on board.

Looking at the Peregrine VRG4 PlainsMaster spitzer, you’ll see a recognizable profile but in a metallic composition that expands even as velocity dips to as low as 1,600 fps — absolutely perfect for long-range shots. This bullet has all the features you’d want to see in a monometal: driving bands for low friction and reduced copper fouling, and a sensible profile for accuracy and retained energy within hunting distances, yet nothing so radical as to pose a

problem for reloaders. It shoots very well in the common medium calibers that are used here in the States — my .300 Winchester and 6.5-285 Norma simply love it — and for an African application I can totally see a Kalahari hunt where the springbok and gemsbok are across the pan, and require the high BC that the PlainsMaster provides.

This ‘plunger’ technology — the idea that a specific nose material needs to be used to initiate expansion — is not new. Think about the Remington Bronze Point, or any of the polymer-tipped bullets that

have become so popular over the last three decades. But Peregrine has revolutionized the concept. All field reports indicate positive results. Both Professional Hunters and their clients alike are more than satisfied with the terminal ballistics of the Peregrine design.

The Peregrine PlainsMaster VRG4.

Aucamp further explained the research and development that went into the Peregrine line, in particular the PlainsMaster bullet.

“Many hours went into the design of the Extreme Long Range bullets

including highly theoretical analysis using the best possible science and engineering simulation tools for such a project," he said. "No test firing happened at all during the first year as the focus was solely on creating aerodynamic related building blocks for CFD (Computational Fluid Dynamics) modeling as well as 6 Degree of Freedom calculations of bullet flight. Once a proper foundation was laid, it was possible to make steady progress from theory to reality and shooting the first test

models to validate the engineering calculations and in-flight predictions.

“We did not want to fall into the trap of exotic or outrageously high BC bullets … due to the fact that either the nose or the boat tail is too long and therefore the bullets are simply not accurate or they are difficult to shoot as a result of extreme sensitivity for that perfect but elusive optimum load.

“Today’s rifles are predominantly manufactured for lead core bullets. In our opinion, there will come a day when lead will be banned worldwide. This we

believe is inevitable and Peregrine would like to steadily grow into the market and be ready to ease the pain of transition into the lead-free future as much as possible. Ultimately, copper will remain as a viable alternative and is by far the most likely long-term solution. With this in mind, we have created high BC bullets that can be used as a drop-in replacement for lead core on existing rifle platforms. And we have created bullets for the long-range fanatic who wants to fit a designer barrel with a slightly faster twist and a chamber to match his favorite monolithic bullet.

“To complement the long-range bullets we have also created a limited series of extreme long-range hunting bullets.”

So, you have a bullet with excellent terminal capabilities, which will more than suffice in the exterior ballistics department. Peregrine is definitely onto something here. I load them for my own rifles, when pursuing Cape buffalo and hippo, and I believe in their abilities, as much if not more than other designs.

The BBW#13 nose profile on the Safari Raptor, in .404 Jeffery.

Cutting Edge Bullets, brainchild of Dan Smitchko, takes the polar opposite approach. Instead of designing a bullet that will be tougher than nails and hold

together no matter what it hits, they designed a bullet that would intentionally come apart. The CEB Raptor is a unique design, one that I've come to trust in the hunting fields. The bullet is designed to be frangible — at least to a point. From the medium calibers all the way up to the safari calibers, the bullet has been engineered to provide a delicate balance of impact trauma and straight-line penetration, which is crossways to the traditional school of thought regarding expansion and penetration. It features a particular nose profile CEB calls the

BBW#13 that has demonstrated the best penetration qualities, and undoubtedly they have something right. There have been many hands in the development of the Cutting Edge line. For example, I have it on good authority that BBW stands for Bastard Bullet Works, with the nose profile being developed by using a bastard file and experimenting with varying angles until the desired result had been achieved. Indeed, those hands have succeeded in developing a bullet that works very, very well.

The Raptor is a monometal, all-copper bullet, lathe-turned affair, designed to come apart once flesh and bone are struck. It's a hollowpoint with a nice, wide hole in the end, and skived walls. This is exactly where the Cutting Edge Raptor deviates from all traditional designs. The bullet is designed to break apart, with the walls of the hollowpoint fragmenting into what CEB calls 'blades.' Those blades cause a significant amount of impact trauma, traveling 8-10 inches deep into the animal in a spiraling pattern. They radiate 6-10 inches from

the center of impact, but the base of the bullet — left at caliber dimension once the walls of the hollowpoint have broken off — continues to penetrate the animal. This may sound like a sketchy scenario, but I’ve seen the bullet work perfectly on a number of species, and at a bullet weight lighter than would be normally called upon for a particular application. Between whitetails, and a half-dozen or so African plains game species, the Raptor has proved itself in a number of different calibers for me.

Many times, while performing the post-mortem autopsy in the skinning shed, all that will be recovered are the blades, as the base of the bullet frequently exits the animal, irrespective of angle. As in the story I related earlier in this chapter, where I used the Raptor in my .300 Winchester Magnum at 150 grains, I’ve loaded this bullet in .375 caliber at 235 grains, in .416 caliber at 325 grains, and in my .404 at 325 and 350 grains. None of these bullets have let me down. In fact, I wouldn’t hesitate to recommend them to any client who

wanted a good bullet for their rifle. I’ve used the .30 caliber bullet to crumple a kudu on the run as well as to ruin a nice waterbuck’s day, as he was lying down, 225 yards away. At the shot, the waterbuck stood, reeled for 10 yards, and fell down as dead as a doornail. That was a small target (with the vitals all squashed as he was lying down), but the bullet was accurate, and gave fantastic terminal performance. Watching a 325-grain .416 bullet penetrate a big-bodied zebra from stem to stern, with the bullet base exiting out of the rear of the animal, engenders a

whole lot of confidence. This bullet

design will gain all sorts of ground in the near future.

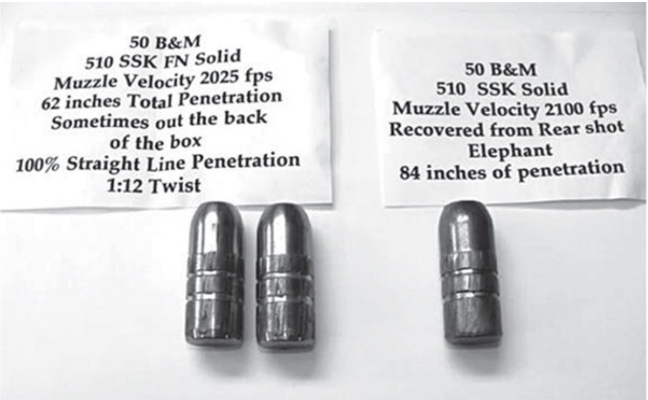
Curious about that BBW#13 nose profile and its origins, I asked Michael McCourry, who had a huge hand in the development of this nose profile, to explain it further. McCourry set out to build a better mouse trap.

“Early in 2006, I took the first 50 B&M Prototype rifle to South Africa for a test run on plains game,” McCourry explained. “This was a 2-inch RUM case at .500-inch actual diameter. We were testing bullets common to the .500 S&W

at the time, 500-grain Hornady at 1800 fps, 400-grain Sierra at 2100 fps, 375-grain Barnes X at 2300 fps, and a few others. Along with these was a 400-grain round-nose solid that JD Jones and I had done by David Fricke of Lehigh Bullets. At the velocities everything ran, results actually exceeded expectations; no doubt that .500 caliber was coming into play here, and far, far ahead of anything I had seen in .45/70. The big ugly disappointment was the round-nose solid, a turned brass bullet. On several occasions — on kudu and eland — the

solid would veer off course as much as 90 degrees and not reach its destination.

Dave deMoulpied and his zebra, which fell to the 354-grain CEB Raptor, from his .416 Rigby.



"This led me into the search for a perfect solid, which was successful in the end. I needed a solid to work with these .500 caliber rifles. That led to an incredibly tedious process of test work. In the beginning, we basically took a similar design to the then newer Barnes Banded

Flat Nose Solid. This was very successful in the new 2.25-inch .500 caliber 50 B&M rifles. I used the bullet on a couple of elephant, and five Cape buffalo in 2007 with extreme success and great depth of penetration, and above all, dead straight-line penetration. However, the search continued to improve even upon this success. At that time I was running this bullet at 2,025 fps in the 18-inch barrel of the 50 B&M.

"JD Jones and I continued to play around with a few different designs over the next couple of years, and I continued

to test and look at all other big bore calibers from .416 to .510 and different designs of solids. Every single solid manufactured and available was tested and we began to learn a great deal of what factors are involved with solid penetration, what did the driving.

“Sometime in either late 2009 or early 2010 I met a fellow named Sam Rose. Sam was extremely interested in bullet technology, and we shared many of the same desires for a solid. Sam is a talented machinist and the fact that he had his own lathe ended up being a huge boost to

our study here. Sam and I came up with some of the wildest-designed solids one can imagine, and we were testing nearly four to five sessions a week for months on end.

"During these studies we conducted one of the most important studies done with solids, a meplat size test to understand at what point we got total stability, simply because of meplat size. We tested a .500-caliber bullet, basically Barnes Flat Nose profile from a round-nose up to 80 percent of caliber meplat size, as I recall. What we learned is that

everything up to 65 percent meplat of caliber was not completely stable during terminal penetration. We started seeing some stability at 60 percent meplat size, but at 65 percent meplat we got total stability and the deepest straight line penetration. At 70 percent meplat we still had dead-straight penetration, but depth of penetration began to decrease, and the same for 75 and 80 percent. We found 65 percent meplat of caliber perfect.

"During this process we also learned that twist rate did have an effect as well. Faster twist gave more stability. But twist

rate only came into effect with lesser meplat size, less than 65 percent. Faster twists would stabilize lesser meplat size for added straight-line depth, it would not fully stabilize for the entire depth of penetration, but it would increase straight-line stability. Twist rate had no effect on proper-sized meplat, 65 percent or better. In fact, I had some oversized barrels here that we tested 65-70 percent meplat size, no engraving on the bullets at all, and meplat size alone stabilized them during terminal penetration up to and sometimes exceeding 90 percent of

the total depth of penetration, and this is with no engraving on the bullets at all.

“We also learned that nose profile made a difference as well, some nose profiles did better than others, some more stable than others, while certain nose profiles increased penetration. And, a radius edge instead of a sharp edge on the meplat made a huge difference as well, not only in depth, but stability at the very end of penetration.

“We were literally testing hundreds of solids a week, and every small step of the way learning new things about how a

solid actually works. Listed below are the absolute known factors involved with terminal penetration of solids, in order of importance to straight-line penetration and depth of penetration in either aqueous test material or animal tissue.

#1. Meplat Percentage of Caliber

#2. Nose Profile

#3. Construction & Material

#4. Nose Projection

#5. Radius Edge of Meplat

Above Factors related to Bullet Design

#6. Velocity

#7. Barrel Twist Rate

#8. Sectional Density

"Now the old diehard convention wisdom always says SD is number one. This is not true at all, and we can prove it time after time, in any caliber. (Author's note: this comment is in reference to 'solid,' or non-expanding bullets.) If a solid is not stable, it will not penetrate in a straight line; it will veer off course, and penetrate less, every single time, as opposed to a properly designed solid. The one and only time that SD becomes a factor at all is when all of the other

factors are dead equal, all the way down the line. Take for instance the very fact that a properly designed 325-grain .458 caliber solid will double the depth of penetration of a 500-grain round nose .458 caliber solid. SD has little to do with the penetration of solids, unless all else is equal.

“Along the way, JD had sent several different designs he was working with in both .458 and .500 as well. One of these was derived from some of his old-time cast bullets that he had used in various JDJs over the years, but now in a .500

caliber copper solid. I had tested this bullet many times and always found it gave 100 percent dead straight-line penetration. One day I handed one of these to Sam Rose, and asked him to measure the degree of the angle off the nose, and for him to make a series of different degrees for us to test.

“Sam went home, measured this bullet and found it was right at a 15-degree angle off the nose. The meplat measured slightly above 72 percent. As I recall, Sam made a variety from 10 degrees all

the way to 20 degrees off the nose and we tested.

This is the original bullet that JD sent.

North Fork followed suit with a similar solid. It too is an excellent bullet.

"All tested well until we got above a 15-degree angle, and then things got a little squirrely. We found that everything between 11 and 15 degrees did very well, was stable. A smaller meplat size of 65 to 67 percent depth of penetration was

incredible compared to other tests we had done. In the end, we picked the 13-degree angle, which was basically in the middle. Now during all this time, teasing Sam, I accused him of making bullets with a “bastard file” as a joke. He was sending several different designs of some really wild stuff weekly.

“The bastard file joke ended up evolving into Bastard Bullet Works, or BBW.

“We also started working very closely with Dan Smitchko of Cutting Edge Bullets. Dan was instrumental in making

the changes we desired, to complete the study with CNC-machined bullets. After many months and many thousands of rounds fired during the test work, we declared the 13-degree angle nose, and 67 percent meplat size bullet the best solid we had ever tested, and the most consistent in all calibers tested. Our mission had been a great success, and it was decided to give the design to Dan at CEB, and let him run with it. In the beginning, he asked what we wanted to name it, I said BBW #13 — “Bastard Bullet Works,” with the #13 after the

angle off the nose. Later, a more proper name was given by CEB, the Safari Solid.

“Having a variety of .500 caliber rifles, including lever guns, BBW #13s were designed for all of my .500 caliber cartridges, from lever to the larger 500 MDM. BBW#13s are available from 375 grains to 550 grains in .500 caliber. Now, #13s can be had in all major large bore calibers up to the big 900 grain .620 caliber for 600 Nitro and 600 OverKill. #13’s have been used extensively in the field on elephant, buffalo and hippo many

times over now, all with extreme success. This is the go-to solid when absolute straight-line deep penetration is required.

"If you notice the bands on these bullets, please take note this was a special area of study, too. Sam was extremely interested in double rifles, and in particular a bullet band design that was "safe" for doubles. I have the capability here of doing pressure work. We hooked a strain gage four inches from the muzzle of several double rifles, and other rifles as well, reduced the loads to where the strain gage would only measure the

passing of any given bullet, and measure the amount of expansion in the barrel as that bullet passed that point. The design you see, in both the Cutting Edge Bullets and the North Fork Bullets gave the least barrel strain overall of any and most all other bullets. We needed the three full diameter bands at the top and one at the rear to maintain accuracy. The more bands that were added, the barrel strain increased. We learned that barrel strain is affected by bullet diameter and bearing surface. Reduce the bearing surface, you have reduced barrel strain, reduce the

diameter, you again reduce the barrel strain. But at some point, you can only go down so far in diameter before affecting other areas like accuracy, stability, and so forth. Brass gives less barrel strain than copper in most cases, all being equal. The North Fork bullets are equal to the CEB in this area because of their reduced bearing surface, even though they are copper-based. The main factors are bearing surface and diameter."

McCourry's testing sheds much light on how bullets behave in both test media and real-world scenarios. I don't have as

many opportunities to test the solids in the field (dangerous game safaris are very expensive) but I’m glad we have folks like Michael McCourry who have a passion for developing the best bullets available.

DEFENSIVE HANDGUN BULLETS

The penetrative qualities of a defensive handgun bullet are even more important than those of a hunting rifle; your life may be on the line and you need it to perform properly. While the distances at which handguns are used are invariably

shorter than those of a rifle, and variations in impact velocities are less, there are certain concerns that need to be addressed. Certainly, you expect handgun bullets to penetrate sufficiently to neutralize a threat to life and limb, but the risk of over-penetration — where an innocent person might be wounded or killed — is a reality. Defensive handgun bullets have their work cut out for them, and the bullet developers have spent copious amounts of time to get the balance just right. Our military has been forced to depend on the full metal jacket

design, as prescribed by the Hague Convention, and while FMJs work in a battle situation, they’re not optimal for civilian needs.

Years ago, we pretty much had three choices: lead, jacketed, or full metal jacket. Yes, they will all still work (the footage of Jack Ruby killing Lee Harvey Oswald with a round-nosed lead slug from a .38 Special at spitting distance is an example) but there are better choices. Premium handgun bullets have been designed for reliable expansion and proper penetration, and the tests prove

just that. There are numerous choices, including the Federal Guard Dog and HST, Hornady XTP and XTP Magnum, Speer’s Gold Dot, Winchester’s Defender and more, but they all have the same common goal: saving your bacon.

Handgun barrels can be almost as finicky as rifle barrels, and it may take a bit of experimentation to find the load that is most agreeable with your own gun. But look at the penetration tests for each load before settling on a brand. Some bullets employ the same construction techniques as premium rifle projectiles:

bonded core, polymer tips, etc. However, not all premium handgun bullets are created equal.

I had an eye-opening experience while a guest at the Federal Premium plant, testing three different models of Federal .45 ACP defensive ammunition into ballistic gel. We had a sweet Kimber pistol that was plenty accurate and an absolute pleasure to shoot. There were boxes of 230-grain Hydra-Shok, 185-grain Guard Dog and 230-grain HST ammunition, and clean gel blocks to observe penetration and expansion. The

Hydra-Shok is Federal's classic hollowpoint, skived to promote expansion and features a small post in the center of the cavity. Guard Dog is designed for indoor situations; it has a rubber insert filling the hollow cavity, and the whole bullet is plated so as to appear like a flat-nosed FMJ. The HST bullet is also a skived hollowpoint, designed to expand into a sharp, flower-like pattern, and the high antimony core holds well to the heavy copper jacket. These bullets were fired into three types of test media: gel alone, gel covered with

clothing layers, and then through two pieces of drywall and into the gel.

All three of the bullets performed very well into bare ballistic gel. Weight retention for the Hydra-Shok was 222 grains, Guard Dog retained a good amount of its weight, coming in at 164 grains, and the HST did as well, weighing 228 grains after expansion. Expansion was consistent, with the Hydra-Shok measuring 0.65 inches, the Guard Dog 0.72 inches, and the HST opening up to an even inch. Penetration was between 12 and 13 inches for the HST and Hydra-

Shok, and 6 ¼ inches for the Guard Dog, so I really didn't have a favorite (yet).

Rifle Bullet Penetration: The Highlights

Sectional density is a good indicator of a bullet's length, but is only one factor. The bullet's construction must be taken into account as well.

High retained weight aids in good penetration, yet expansion

is required for the destruction of vital tissue. What you are looking for (in the big game world) is the consummate blend of both qualities.

Modern construction techniques have truly changed the game. Bonded core, partitioned, and monometal designs have a structural integrity superior to the traditional cup-and-core ammunition.

Traditional cup-and-core bullets work fine if of suitable length (sectional density) and impact velocities aren't too high for the bullet's construction. For long-range work, the bullet slows down considerably, but close shots can make a mess of things.

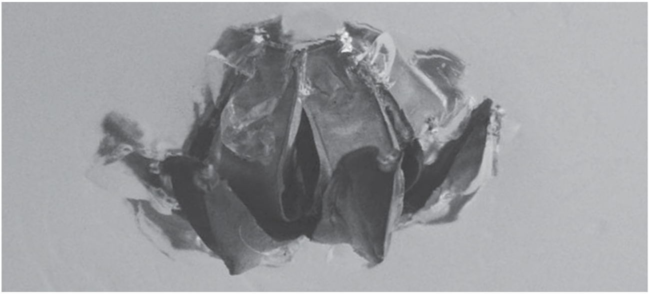
Round- and flat-nosed bullets — with a larger contact diameter — can facilitate better energy transfer, and that difference can

be seen upon impacting a game animal.

Round- and flat-nosed bullets have demonstrated an advantage in straight-line penetration, but suffer in the exterior ballistics department due to low BC. A compromise must be made if your hunting ranges are past 200 yards.

The newer, more radical designs, like the Woodleigh Hydrostatically Stabilized Solid, Peregrine BushMaster and

Cutting Edge Bullets' Raptor deviate from traditional thinking, but warrant a place among the best bullet available; further proof that bullet technology is at the forefront of evolving hunting gear.



The Federal HST expanded in ballistic gel.

The trio of Federal bullets after being fired through clothing.

The clothing test revealed a different story. The Guard Dog expanded reliably, to 0.70 inches, and retained 163 out of 185 grains, but penetration was cut down to 8 ¼ inches. The Hydra-Shok retained 227 grains, but expansion was reduced to

0.65 inches and penetration was 13 inches. However, the HST retained 227 grains, expanded to 0.82 inches, and penetrated 14 inches of gel. At that point I was starting to form an opinion.

The drywall test sealed the deal for me. The Hydra-Shok didn’t expand at all, and the bullet could more than likely be re-fired. The weight after recovery was 232 grains, as it was filled with gypsum. The bullet penetrated 24 inches of gel block, and was recovered downrange about 15 yards. The Guard Dog expanded to the same dimension of 0.70 inches, and

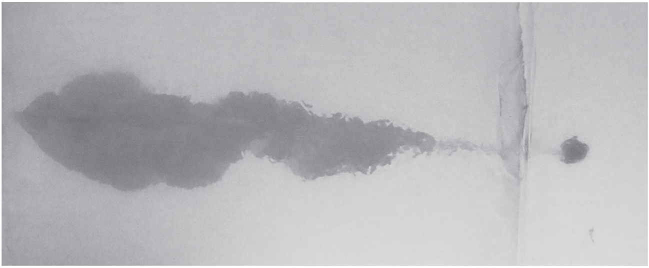
weighed 170 grains, but didn’t penetrate more than 8 ½ inches, completely in line with the design of the bullet and loading. The HST weighed in at 228 grains, despite the wallboard, and expanded to 0.81 inches, with a full 8 inches of penetration. It was the jagged edges of the expanded HST, along with the nasty wound channel created in the gel that made me favor this bullet. If I was forced to shoot indoors, and over-penetration was an issue, I think the Guard Dog line of ammo might be your baby. But for an overall self-defense bullet, in the Federal

line I prefer the HST, for the reason of the expanded shape. While the Guard Dog was very reliable, the HST, with those razor sharp petals, will undoubtedly decimate the enemy and “chastise with extreme prejudice,” to borrow a military expression. I carry this ammunition confidently.

Cutting Edge has adapted their fragmenting bullet concept for handguns, in the Handgun Raptor. It’s available in both component form and the Personal Handgun Defense (PHD) line of loaded ammunition. Using a bullet weight that is

much lighter than normal at a higher velocity, the Handgun Raptor causes that same upfront trauma from its blades, while the caliber-sized base drives deep penetration. I’ve tested these in 9mm Luger (90 grains), .40 S&W (120 grains), and .45 ACP (150 grains). They work as prescribed, with the nose section reliably breaking off upon impact, and the base giving 8-12 inches of penetration, depending upon the caliber and the test media. If you’re a fan of higher velocities and want dependable penetrative qualities, I recommend you try these

bullets, and test them for yourself. I like them, and believe that they will quickly and handily neutralize a threat, in spite of the lower SD figures. It would be worthwhile to do some informal penetration tests with your chosen load, even if it’s just shooting into some wet phonebooks or tightly packed newspaper, so you have an idea of the penetration capabilities.



Federal HST in ballistic gelatin.

The Cutting Edge PHD ammunition, featuring the 9mm Handgun Raptor bullet.

The PHD ammunition is designed for handgun personal protection. Loaded with the lead-free HG Raptor bullet; after 1.5 - 2 inches of penetration four blades are engineered to shear off and radiate out in a star pattern while the Blunt Trauma Base continues to penetrate up to 14 - 16 inches in ballistic gel.

HANDGUN HUNTING BULLETS

When it comes to hunting with a handgun, reliable penetration is paramount. I like the more powerful revolvers like the .357 Magnum, .44

Magnum and .45 Colt. Bump up to the bigger cases, like the .454 Casull, .460 S&W, .500 Linebaugh and .500 S&W, and you'll see the obvious need for a bullet of high sectional density, if it is of cup-and-core construction or traditional hardcast lead. Companies like Buffalo Bore, DoubleTap and Garrett Cartridges have long offered hardcast hunting bullets for these cartridges and, at moderate velocities — usually below 2,000 fps — they work just fine and penetrate wonderfully. However, as we have shown with other examples in the

rifle calibers, impact velocity can be the downfall of penetration, especially with expanding bullets.

Many of the rifle bullet companies offer handgun choices, which work as well as do their big brothers. Swift’s A-Frame is available in most popular revolver calibers from .357 upward, as is the Barnes XPB monometal. Cutting Edge offers the Handgun Raptor as a configuration optimized for the handgun hunter, and these happen to be a favorite of my pal and fellow gun writer Matthew

Cosenzo. He started using CEB Raptors in his .44 Magnums.

“Over the years of hunting with pistol caliber rifles — specifically the old .44 Magnum carbines by Ruger — I have developed strong opinions on bullets choices, which translated over when hunting with handguns,” said Cosenzo. “Within those particular rifles you should only shoot jacketed bullets due to the gas system, so when you are pushing a pistol bullet to higher velocity you need to be aware of its limitations. I always shot the 280-grain Speer Deep Curl soft point, an

extremely tough bullet as well as accurate, in my particular rifle, consistently shooting ¾-inch groups. It is my opinion that this particular bullet is too tough for pistols to achieve reliable expansion. Over the years, seeing unimpressive results from jacketed pistol bullets I looked for a better mouse trap. Nearly all pistol bullets expand in the same manner, creating a mushroom, which in turn slows the bullet down as it penetrates, not always giving you two holes.

“The guys over at Cutting Edge Bullets and their Raptor line of handgun bullets are what you will see me load when I am out chasing game. While I have always been a heavy-for-caliber cast bullet guy, the Raptors have changed my opinion of what is necessary, in regards to weight. My initial introduction to these bullets was in the .44 Magnum and what was available was a 200- and 150-grain Raptor, in addition to a 240-grain solid. I immediately knew the 150 had to be too light, though Dan Smitchko, president of Cutting Edge, made me eat my words

that season. He shot a nice-sized doe at about 100 yards and the base as well as the blades exited on this whitetail. The bullet was traveling roughly 1,800 fps from a Thompson/Center Contender. So, even with the lighter weight, depth of penetration was not a factor, nor was the terminal effectiveness, if applied properly. Since all theses bullets are machined on CNC lathes, they have the advantage of consistency and repeatability not matched by any other form of manufacturing. When it comes to jacketed bullets in revolvers you need

that bullet to function exactly the same way every time; this is a common gripe by many seasoned handgunners. Raptors give me that uniform performance."

Now, Cosenzo is no stranger to hunting with a handgun. And he has grown to swear by the Cutting Edge Handgun Raptor, in several different calibers, including the .500 Linebaugh. While the bullet runs light-for-caliber (lower sectional density) in comparison to hardcast lead projectiles — as most all-copper bullets do — it has the structural integrity necessary to make a quick kill.

CHAPTER 16

KINETIC ENERGY AND KILLING POWER

We hunters simply love to quantify things, right down to the last detail. We’re also fond of assigning minimums, rules, absolutes, quotable lore, and arguing over these points. Kinetic energy figures are no exception. And while there is merit to using enough gun with

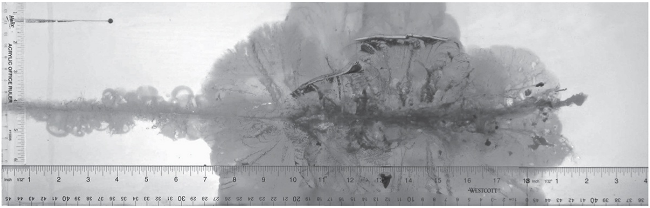
sufficient kinetic energy, these figures can be misleading.

First of all, the kinetic energy of a bullet is measured in units of foot-pounds. The equation to derive the energy of a particular bullet is as follows:

$$\mathbf{KE=(M \times V^2)/450{,}435}$$

Whereas KE = Kinetic energy in ft.-lbs., M = the mass of the bullet in grains, V = bullet velocity in fps, and the denominator of 450,435 being a product of gravitational acceleration (32.173 fps^2)

multiplied by 7,000 (to convert grains into pounds) and doubled.



An example: Nosler’s Trophy Grade ammunition in .30-06 Springfield launches a 180-grain AccuBond bullet at 2,750 fps, so the calculation is as follows: $(180 \times 2{,}750^2)/450{,}435 = 3{,}022$ ft.-lbs.

What does that bullet have left at 200 yards? Nosler indicates that it will slow down to 2,400 fps at that range, so

crunching the numbers again will yield: $(180 \times 2{,}400^2)/450{,}435 = 2{,}302$ ft.-lbs.

Let’s take it out to 400 yards, where Nosler indicates a velocity of 2,078 fps, so: $(180 \times 2{,}078^2)/450{,}435 = 1{,}726$ ft.-lbs.

At 600 yards — past my own personal hunting limits — the AccuBond is still traveling at 1,782 fps, therefore: $(180 \times 1{,}782^2)/450{,}435 = 1{,}269$ ft.-lbs.

However, while these figures are absolutely correct, do they translate directly into killing power? In reality, they give a good representation of the

potential, but favor velocity. Allow me to explain.

If you take a .45-70 Government loaded with a 405-grain flat-nosed slug moving at 1,330 fps — à la Remington's load — you can crunch those numbers and arrive at 1,590 ft.-lbs. of energy. If you then look at a .22-250 Remington, driving a 55-grain bullet at 3,680 fps — like Hornady's Varmint Express ammo — you will see 1,654 ft.-lbs of kinetic energy. Facing an enraged grizzly bear in an Alaskan willow thicket, which bullet is going to kill that bear quicker? I can

confidently say that almost anyone would opt for the .45-70, unless you are the bear whisperer. So where do you go wrong with your dependence on kinetic energy figures? Or, does speed truly kill, and all is right in the world with these numbers?

I personally only see the flaws in dealing with kinetic energy values, as the above example clearly demonstrates. I’m not the only one who has noticed the issue; a gentleman with much more experience dealing with big rifles and bigger animals developed a newer system before my father was born. That man was

John Taylor, author of *African Rifles and Cartridges*. Taylor spent most of his adult life in wild Africa, mostly in Portuguese East Africa (modern day Mozambique), and was privileged to experiment with a large number of calibers and projectiles on all sorts of game, for an unparalleled collection of ballistic experiences. I like several things about Taylor. Aside from the fact that he was a major inspiration for my near-addiction to African big game hunting, he too was a lifelong student of ballistics. He was also a bold soul, abandoning the traditional system of

measuring the striking capabilities of cartridges by using solely kinetic energy, and developed his own Taylor Knock-Out Factor. This formula varies from the kinetic energy equation in that the gravitational acceleration is removed and the bullet’s diameter introduced. The Taylor Knock-Out Factor formula works as follows:

Taylor KO= (M x V x D)/7,000

Whereas M = mass of the bullet in grains, V= velocity in fps, and D= diameter of the bullet in inches, and dividing that product by 7,000 converts grains into pounds. The Taylor KO factor is a unitless figure, used to compare the potential killing capability of a variety of cartridges. However, the method does have flaws, as it heavily leans on bullet diameter, and I sort of understand why. In Taylor’s day, there was a serious divide between the ‘small bore at hyper velocity’ crowd, and the ‘as big as you can launch at a moderate velocity’ camp.

In a time when even P.O. Ackley was touting the .220 Swift as the greatest thing since sliced bread, and Walter Bell's 7x57mm Mauser had already accounted for the majority of his 1,100 elephant bulls, there were people stretching the limits of bullet weight/construction/velocity boundaries. Bell used only solids. I believe he uttered the phrase, "my barrel has never been polluted by a soft-point bullet." The soft points of his day were questionable, especially on dangerous game, and survived his time among the elephants

unscathed, but no one today would try that stunt, even with super bullets like the Woodleigh Hydro Solid. So Taylor compiled his formula to represent how he felt; it is scientifically skewed, but is a little bit better than the kinetic energy ideas. Let’s look at why.

Using Taylor’s formula and muzzle velocities, the .30-06 Springfield has a TKO value of 21.8, while the .45-70 Government is 35.2. I get the fact that the heavier bullet and increased frontal diameter have an effect, but I don’t know about a 62 percent increase in

performance. Even the .35 Remington, launching a 200-grain bullet at 2,100 fps, yields a TKO rating of 21.1, essentially putting it on plane with the .30-06, and I don’t see that as correct. I understand Taylor’s intentions, but their flaws are hard to ignore.

Looking at the quantifications even further, there is no method available that takes the bullet construction into account. Certainly, if you were to compare the same .30-06 Springfield, shooting 150-grain bullets at a particular game animal (let’s just pick a mule deer for

demonstrative purposes) and used two different styles of bullets, you would definitely have different results. Assuming a good bonded-core spitzer, like the Swift Scirocco II, I'd feel confident taking a shot from just about any angle offered, knowing the bullet's construction is no issue. Swap that bullet out for a Sierra 150-grain MatchKing, a bullet celebrated for its accuracy, but marginal terminal ballistics, and you'd have good cause for concern — likely breaking apart on the first bone encountered. Now, that's not to suggest

that mule deer are bulletproof, but it goes a long way to show that some methods of measuring killing power can be a huge waste of time, especially when it comes to making an argument for or against one cartridge over another. Invariably, the kinetic energy method is the most common today, so I'll concede the fact and use it to draw some conclusions.

There are established minimums, figures that someone — I truly have no idea from where or whom these originate — set for various game animals. You've heard these before: 1,000 ft.-lbs. for a

deer, 2,000 ft.-lbs. for an elk or moose, 4,000 ft.-lbs. for Cape buffalo, elephant and other dangerous African game. Back to the need to quantify things, and the fact that a line had to be drawn somewhere, I can see that perhaps these figures aren’t exactly out to lunch, but they are certainly not absolutes. A modern big game compound bow, set up for hunting grizzly bear, uses an arrow weighing a total of 500 grains, give or take a few, launched at 250 fps. Based upon the formula for kinetic energy, this combination generates a whopping 55.5

ft.-lbs. of energy. Yet we all know if that arrow is properly placed it will most certainly kill the grizzly. So, I think it's also fair to bring the aspect of tissue destruction into the mix. Returning to the .30-06 Springfield on a mule deer hunt example. Imagine the difference in tissue destruction if you compared that Swift Scirocco II with an average expansion rate of just over twice the caliber dimension (assuming a shot somewhere between 100 and 200 yards), and a full metal jacket bullet offering all sorts of penetration yet absolutely no expansion.

Both bullets have the same kinetic energy figures, as well as the same sectional density figures. But I still think hunters prefer the bonded core expanding bullet.

Instead of subscribing to the hard-lined minimums and basing your facts and decisions on decades-old bullet technology, you should blend all the aspects discussed thus far and come to a common sense conclusion. You need to use the kinetic energy figures as a baseline, thinking about bore diameter, bullet configuration and construction, sectional density figures, etc., and police

yourself. In other words, would the .243 Winchester make a good elk or moose cartridge? At 100 grains of bullet weight, I don’t think so. I know people who’ve killed elk with the little 6mm, but I don’t think it’s an ideal, or even a wise choice. Do you need a .338 Winchester Magnum to kill that elk? Not necessarily, but I’d definitely prefer the larger cartridge over the smaller.

Bringing everything we’ve discussed into play, from trajectory and wind deflection values, to bullet stability factors, to sectional density and all other

penetrative dimensions, to the skewed means we have on hand to determine the killing power of a bullet, you need to look at the whole gem, instead of one facet at a time. For most hunting situations, one of the classic cartridges will more than likely fulfill all of your needs. While the .30-06 Springfield has been used, is used, and shall be used by an enormous amount of hunters (because it just plain works), if the .300 Dakota, .308 Norma Magnum or .300 Winchester Short Magnum floats your boat, there’s no problem with that. There are

availability issues, but all of those cartridges will push a .30 caliber bullet to respectable velocities, and give perfectly suitable field performance. If you prefer the 6.5 Creedmoor over a traditional 6.5x55 Swede, so be it, as the performance is relatively similar. Just don’t expect to ask a .25-06 Remington to do the work of a .338 Magnum; you can only push the envelope so far. There’s an awful lot of overlap in our modern cartridges, and I hope that with the information I’ve covered thus far will

not only help you recognize that fact, but make an informed choice of cartridge.

There is one place where the line has been drawn, and unfortunately it’s a legal line, so there’s no fighting it. However, like all lines drawn, there are reasons to question it, and there are shortcomings to the logic. Most of the African continent has a law stating that a .375 bore shall be the legal minimum for hunting all dangerous game. While I understand the *intent* of this law, it does a couple of silly things.

First off, it precludes the use of the 9.3mm (.366-inch diameter) cartridges; classics like the 9.3x62mm, 9.3x64mm and 9.3x74R that have long given reliable performance on the biggest animals on the Dark Continent. Secondly, while the intent of the law (I assume) was to create a minimum performance level, as represented by the .375 H&H Magnum, it doesn’t specify any sort of energy or momentum levels. So, in theory, you’d be perfectly legal using a lever-action Winchester 94 Big Bore chambered in .375 Winchester pushing a 220-grain

bullet at 2,200 fps. Yet, you’d be technically breaking the law by using a 9.3x64mm Brenneke, driving a 293-grain bullet to a muzzle velocity of 2,580 fps; a formula very, very close to the .375 H&H setup of a 300-grain bullet at 2,550 fps.

Add some other oddballs into the mix, like the .405 Winchester, which Theodore Roosevelt loved so much. It uses a 300-grain .411-inch diameter bullet (of relatively low SD) at 2,200 fps, and while it does make the legal minimum for dangerous game, it doesn’t make the wisest of choices for Cape buffalo, and

certainly not for elephant. Pick a cartridge that uses a bullet of sensible sectional density, preferably over 0.300, of suitable caliber and velocity. African game can be rather, well, unforgiving, and your safety is paramount.

The reason that the .375 bore was chosen for the benchmark was more for its performance level than its diameter. And you’d do well to make sure you choose a cartridge that can at least mimic that power level. The commonly accepted energy level for dangerous game is 4,000 ft.-lbs. (the energy level of the .375 H&H

using 300-grain bullets) and upward. I can agree with that figure so long as the bullet has a decent sectional density. African dangerous game is one area where bigger is most definitely better.

Back to the idea of a minimum energy level for common game like deer, I’m not quite sure the old adage of 1,000 ft.-lbs. as a minimum holds water. Considering that a deer is highly susceptible to shock, and that modern bullet construction has changed radically, any given energy figure may be misleading. I also feel that these ‘minimum energy’ rules we all

consider to be gospel can be skewed to make the case for extreme long-range hunting. Federal Premium's 180-grain .300 Remington Ultra Magnum load yields 1,040 ft.-lbs. of energy at 950 yards, but that is certainly no excuse to shoot game at that distance. In addition, bullet construction plays no part in that minimum energy level figure, though it does play a huge part in the terminal ballistic phase of the equation.

The same can be said for the elk figure of 2,000 ft.-lbs., which is odd considering that the elk is considerably larger — up

to five times that of a deer — and somewhere along the line someone figured that 2,000 ft.-lbs. seemed a good number to settle upon. Looking at the Federal load in 7mm Remington Magnum, using the tried-and-true 160-grain Nosler Partition bullet, you'll see that at about 325 yards the energy levels drop below the 2,000 ft.-lb. mark. I know many people who have very effectively taken elk with a 7mm Mag. at distances past 400 yards, where the energy figures would have dropped off to less than

1,700 ft.-lbs. yet the animal was as dead as a doornail.

The .375 H&H Magnum. It’ll do anything you ask of it.

The behemoth .300 Remington Ultra Magnum.

The point? Energy figures are a *means*, but not the definitive means, of measuring the killing power of a particular bullet/velocity combination. Speed does contribute to the killing ability of a bullet, but only to a certain point. Bullet diameter is another contribution, so long as it has the sectional density to allow the bigger projectile to penetrate properly. There’s always a happy medium to be found for

any game animal; and that’s why the classics are the classics. Be sensible about it, and don’t try to kill an elephant with a sewing needle, nor swat a fly with a sledgehammer.

SECTION IV
TOOLS & TIPS

SECTION IV: **GUNDEX®**

CHAPTER 18

HANDGUN CARTRIDGES

CHAPTER 19

READING THE WIND

CHAPTER 17
TOOLS FOR BETTER BALLISTICS

Even though you’re now armed with all this knowledge, you’re still going to need the right tools to get the job done. I’m assuming your rifle is in working order, and that all is as it should be. Providing that the platform functions properly, your bullet — whether a round-

nosed hunting slug or the most modern hybrid ogive match bullet — will tell the true story once it’s sent on its merry way. The pressure will drive it down the barrel and it will go where you’ve told it to go. Where you tell it to go is largely a matter of your skills. But, there have always been aids or methods of fine-tuning the ability to place a bullet accurately.

The Winchester Model 94 AE-XTR.

A vintage Weaver 2-5x variable riflescope.

I remember as a young man hunting deer with my dad. The first gun I used

was his old Stevens break-action single-barrel shotgun, loaded with Foster-style slugs. It had a 30-inch barrel and a silver bead on the end, and kicked like the hammers of hell. Recoil aside, and excluding the fact that Ol’ Grumpy Pants’ shotgun action was as loose as a goose, the aiming system sucked. Holding that bead on the bull’s-eye, I could maybe, just maybe, keep my shots in a pie plate at 30 yards. But, as GP said, “you’ll be sitting in the thick stuff, so they’ll be close.”

Switching to an iron-sighted Winchester Model 94 in .30-30 WCF made a world of difference. The traditional front post and buckhorn rear sight seemed precise in comparison to the silver bead on the shotgun, and I was pretty good to 75 yards. Scoping the rifle — it was one of the AE, or angled eject models, so mounting a scope over the center of the bore was no problem — enabled even farther shots. I was shooting minute-of-softball at 125 yards with a fixed 4x scope, and now had a deer gun that would do respectable work in the

woods of the Northeast. Thus began my addiction to optics.

A fixed 8x Redfield on a Ruger No. 1V rifle.

RIFLESCOPES

Don’t get me wrong, there is absolutely nothing wrong with iron sights; I still use them, and actually prefer them for dangerous game like elephants or follow-ups on Cape buff, or game hunted at close distance such as black bear over bait. But invariably, I am a better shot when shooting a rifle with a scope onboard. For serious target work, there’s no debating the fact: you’ll want the best scope you can afford, and as

distances increase, necessary options follow suit. You need to properly see the target in order to hit it, and there are actually physical issues involved at longer ranges if your riflescope isn’t calibrated correctly. A riflescope is so much more than just a magnifying glass screwed to the top of your rifle; it is a measuring tool, and a precise means of aiming that removes the focal issues involved with iron sights. Trying to focus three objects simultaneously — front sight, rear sight and target — becomes much more difficult as your eyes age. I

know that at 45 years old my eyes are most certainly not what they were when I was 18 or 20, and I’ll take any advantage I can get when it comes to precise aiming.

Today’s riflescopes are leaps and bounds above those of 50 years ago. The variable power range scopes of yesteryear were plagued with all sorts of issues. Chief among them was a shifting point of aim as you changed the magnification level. Add to that a lack of structural integrity, with heavy-recoiling rifles causing them to lose ‘zero,’ and you’ll

easily understand why early telescopic sights were shunned by some experienced hunters of the mid-20th century. I remember reading one of Hemingway’s hunting stories, in which another hunter suggested the use of a riflescope. “Those things are for nuns and virgins,” Papa said. In his book, *Horn of the Hunter*, Robert Ruark had such trouble with his scope shifting point of aim that he took it off the rifle mid-safari, and left it off for good.

Fixed power riflescopes were much more dependable than their variable-

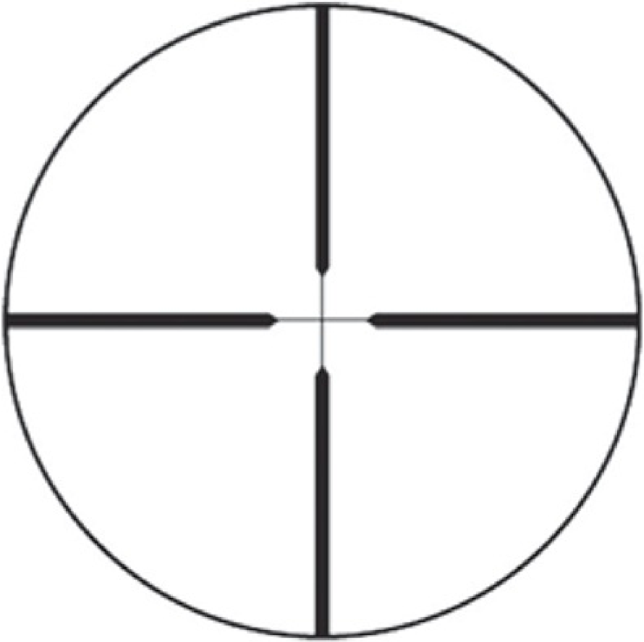
powered brothers, and for years the fixed 2.5x and 4x ones were standard issue for hunters, with the target and varmint crowd embracing the 6x, 8x and 10x fixed-powers. If you’ve ever tried to use a riflescope from the 1940s or 1950s, you’ll appreciate the modern advancements in optics. With the exception of a very few, highly expensive models of that era — Unertl, Bausch & Lomb, Kahles and Swarovski — most left quite a bit to be desired. All that has changed. Even today’s inexpensive optics offer quite a value to the hunter or

recreational target shooter, and the high-end models are nothing shy of amazing. Let’s look at the dynamics of the modern riflescope, and correlate all that information to help you get your bullet properly placed.

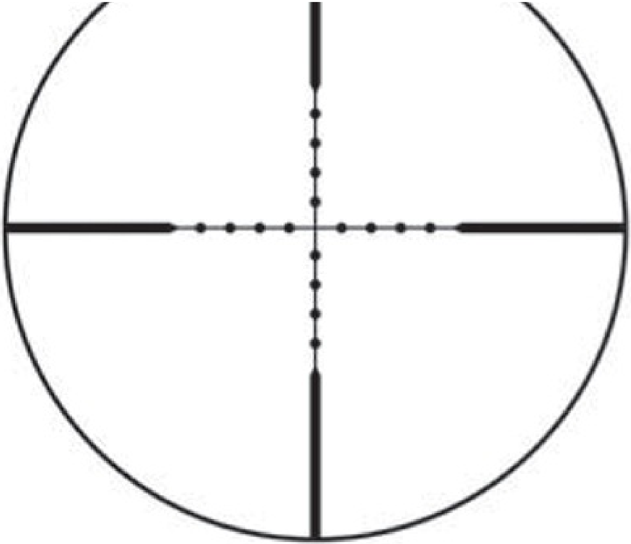
A riflescope contains a series of lenses, designed to provide two things: first, some amount of magnification; second to superimpose an aiming system onto the target so that the target and aiming system are all on one plane. The lenses are contained in an aluminum tube (some older models used steel), with a means of

adjusting the horizontal and vertical positioning of the aiming system. That aiming system, known as a reticle, is a set of crosshairs, or occasionally a post or centered dot. All lens systems have an inherent problem if not precisely focused. This condition is known as parallax, and will cause the image to be seen at one reference point within the riflescope, when in reality it truly lies at another point. This phenomenon will cause all sorts of problems at longer ranges, unless your riflescope has an adjustment to compensate for the change in focal point.

Most modern riflescopes are equipped with an adjustable objective lens or parallax adjustment knob, or are set to be parallax free at 150 yards, and that will cover a considerable amount of your hunting and shooting duties. When distance stretches out beyond 200 yards, the parallax can become a problem. Just like choosing a bullet that best suits your shooting distances, you’ll need to think about the optics system that works best for you.



The Bushnell Duplex reticle.



The mil-dot reticle. There is exactly one milliradian between the centers of each dot; it can easily be used to make accurate trajectory and wind calls.

The same can be said about the reticle. These days, reticles come in all shapes and sizes, some illuminated for use in low-light situations or on a black target like a Cape buffalo or black bear, others resemble a World War II submarine periscope, with all sorts of tick marks, graduations, numbers, dots, additional crosshairs, and more. Some have so much going on in there that they look like abstract art. But, they all serve a purpose, which we'll see shortly. How much or how little you need depends on what you're asking of your rig.

The original crosshairs, two simple wires running horizontally and vertically, have taken a back seat to the duplex reticle, where the thin, inner wires change into a thicker wire as you move away from the center. Most of my rifles are equipped with this style of reticle, and it works just fine for most of my hunting duties. However, other than using the point on the wire where the thin transforms into the thick, there’s not a lot of measuring capability with a duplex reticle.

The ‘Ballistic Drop Compensated’ or BDC reticle is becoming increasingly popular, refining the early developments that gave the hunter a little bit more than the traditional crosshairs. The modern BDC sports a series of graduations on the lower post of the vertical wire, in some increment of measure, to aid you in holdover, compensating for the trajectory drop. Additionally, you will find models with graduations on the horizontal wire, used for measuring an amount of wind deflection, or for obtaining a proper lead on a moving target. Some of the

graduations are mil-dots, or a series of dots subtending one milliradian — a military measure of angle equal to one one-thousandth of a radian. You’ll see mil-dot reticles, as well as those using minutes for a measuring system. While minute of angle, or MOA and the divisions thereof are the most common method of measuring angles in riflescope adjustment, many of the so-called tactical riflescopes have their adjustments in 1/10th mil, rather than in MOA.

Either method is perfectly acceptable. You just have to understand how the

measurements correlate to your target. Both measure the amount of angle that will be subtended by a specific distance on the reticle, and that same mathematical relationship applies to the adjustments on your riflescope. A minute of angle is 1/60th of one degree of a circle, while a milliradian is 1/1000th of a radian. To bring you back to geometry class, a radian is that portion of a circle where the arc length is equal to the radius. To put it in a different light, there are 21,600 minutes of angle in a complete circle, while there are (approximately)

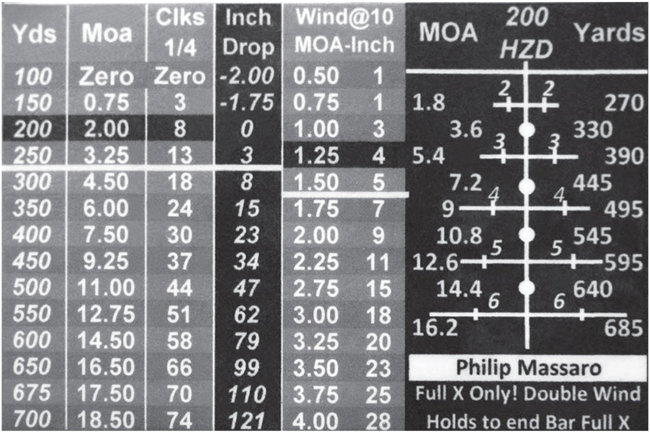
6,283 milliradians in a full circle. So, the milliradian is equal to 3.44 MOA. Putting this in real world terms, one MOA at 100 yards will subtend 1.047 inches, while one milliradian will subtend 3.60 inches. Looking at a mil-dot reticle, you can see how knowing the distance between the dots (derived by multiplying the sine of the angle by the distance to the target) will greatly aid in adjusting your hold for a particular wind call, or adjusting for drop caused by gravity at longer distances.

These same graduations are located within your adjustment turrets. The turrets will be marked in a particular fraction of angular measurement. In MOA-graduated scopes, the most popular graduations are ¼ MOA, though I’ve seen 1/8 MOA on the finer varmint/target styles, and many of the low-power ‘safari’ type scopes still have ½ MOA graduations. Mil scope turret graduations are more likely to be 1/10 mil, or about 0.36-inch at 100 yards. The ¼ MOA graduations are a bit finer than the 1/10 mil, but both are precise. I’ve worked as

a licensed land surveyor since I was 11 years old, so my mind thinks in terms of minutes of angle. I can convert into mils without too much trouble, but for me it’s like speaking a second language; I’m constantly translating it in my head. I’ll explain both systems, in reference to the graduations on a riflescope, but don’t be surprised if you see my preference for minutes over mils.


300-
200-
4
2
0
DOWN

Graduated turret on the Bushnell LRHS scope.



Yds	Moa	Clks 1/4	Inch Drop	Wind@10 MOA	Wind@10 Inch
100	Zero	Zero	-2.00	0.50	1
150	0.75	3	-1.75	0.75	1
200	2.00	8	0	1.00	3
250	3.25	13	3	1.25	4
300	4.50	18	8	1.50	5
350	6.00	24	15	1.75	7
400	7.50	30	23	2.00	9
450	9.25	37	34	2.25	11
500	11.00	44	47	2.75	15
550	12.75	51	62	3.00	18
600	14.50	58	79	3.25	20
650	16.50	66	99	3.50	23
675	17.50	70	110	3.75	25
700	18.50	74	121	4.00	28

The author's dope card for the 6.5-284 Norma, with a Swarovski Z5 BRX reticle.

Let’s use the ¼ MOA graduation as an example for the purposes of sighting in your riflescope. Assuming you’re shooting at 100 yards, where 1 MOA subtends 1.047 inches (we can round this off to an even inch) you’ll need four clicks to make one minute and move the crosshairs one inch. However many inches you need to move your crosshairs at 100 yards, simply multiply by four, as ¼ MOA is equal to ¼-inch at this distance. At 200 yards, the inch value doubles, where ¼ MOA is equal to ½-inch, and so on and so forth. In mils,

you’ll change the value to ⅓-inch at 100 yards for every 1/10th mil click. At 200 yards, 1/10th mil is equal to ⅔rds of an inch, and on and on. Now, while you may be familiar with adjusting a riflescope, as the methods haven’t really changed in 75 years, there are some different ways of measuring with a scope’s reticle to adjust for both wind and holdover.

Thus far, I’ve given you the trajectory and wind deflection values in inches, as it’s our common unit of measure, but many of the long-range shooters measure in minutes or mils, and make the

adjustments by using the turrets of their scopes, rather than estimating distance within the reticle. I learned holdover for distant targets by knowing the drop of my particular load, and adjusting that amount of elevation based on the size of my target, whether a game animal or paper target; my method isn't nearly as accurate as using a Ballistic Drop Compensated reticle or having target turrets to 'dial up' the necessary amount of minutes or mils. In all fairness, when I started shooting, I couldn't afford the premium riflescopes. With a good dope card or a Kestrel Elite

handheld unit, the trajectory and wind deflection values can be represented in minutes or mils, so you can adjust the riflescope a prescribed amount, and hold the crosshairs directly on the target — rather than my method of elevating the crosshairs, which is really the only possible method with a duplex reticle. Or, if you have one of the reticles I'm about to describe, you can look at your trajectory as a function of minutes. Instead of thinking "I'm six inches low at 300 yards," you can view it in a different light: "this rifle is two minutes low at 300

yards," and hold an alternate crosshair or dot to completely and quickly measure with a modern reticle, and a good target turret.

Target turrets are much larger than traditional ones, and do provide a firm grip. Many of the modern models have large, easily visible numbers, for precise adjustments. As is evident, these newer riflescopes have evolved into a totally different animal, with parallax adjustments, high magnification, and larger turrets for on-the-fly adjustment of both elevation and windage. Compared to

my grandfather’s fixed 4x, this is a quantum leap in technology. Let’s look at several of these reticles, and delve into

how they can help you get that little bullet onto the distant target.

MODERN RETICLES

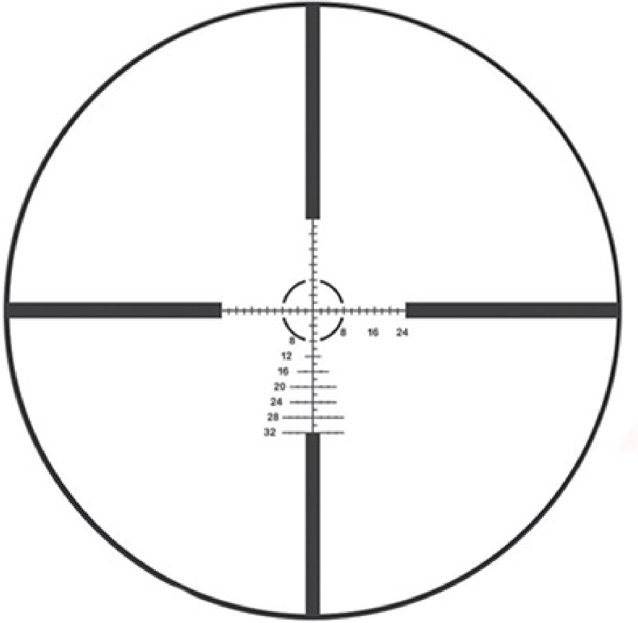
There is a fundamental difference in variable scopes, which is very important to understand before using a graduated reticle. Those are first focal plane and second focal plane reticles. Both have a place in the shooting world. Boiled down, the first focal plane reticle will increase or decrease in size as the magnification is raised or lowered, and if there are graduations on the reticle, they can be used at any magnification level. The

graduations remain constant relative to the size and distance of the target, but are difficult to see at the lowest magnification. Second focal plane reticles are the most common in the United States, and this style leaves the reticle the same size throughout the magnification range. This is the style of riflescope of which I’m most accustomed, but it comes with a caveat: It must be used at a specific magnification value or the calibration will be way out of whack. Typically, such scopes are calibrated to be used at maximum power, but I’ve seen

a few that use a slightly lower value, and were clearly marked to reflect that.

The type you choose is entirely up to you. First focal plane reticles allow you to use the graduations at any magnification, but when the magnification is set low — like you'd use on a close shot — the graduations aren't really needed. At long ranges, you'd be inclined to adjust for trajectory or wind deflection. And you'll have your scope dialed to a higher magnification, so it's kind of a push in comparison to a second focal plane. Playing devil's advocate,

second focal plane scopes somehow like to find their way to a different zoom level. Maybe it’s just me, or maybe Murphy was a distant relative of mine, but it seems that if something can go wrong with a piece of gear in my hands, it will. Either way, once you’ve made your choice, read and re-read the literature available for the scope, so you can fully utilize its potential.



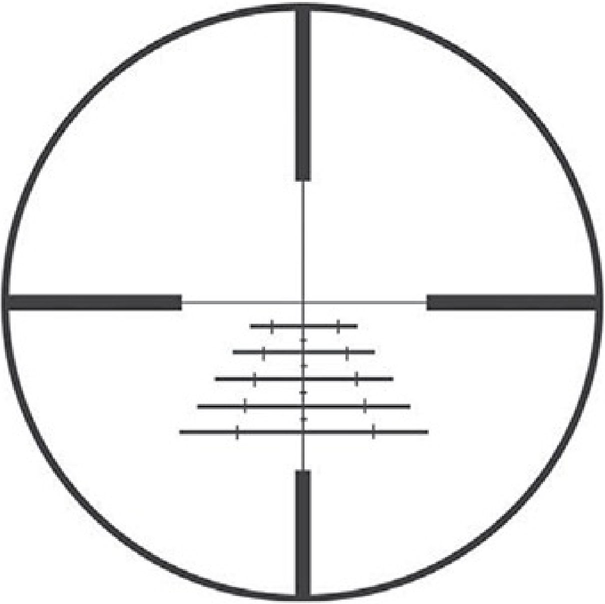
The Bushnell G2M reticle, in a first focal plane scope.

There are many different styles of modern reticles, but I’ll highlight some of those that I find the most useful. It’s no slight to other models, but there’s only so much room here. Bushnell’s G2M reticle, found in the Elite Long Range Hunter, makes a heck of a lot of sense to me. It’s a first focal plane duplex reticle featuring 2 MOA graduations on the horizontal crosshair for 24 MOA either side of center, and a series of holdover crosshairs on the lower vertical wire for 32 MOA. The scope features a 30mm tube, allowing better light transmission, and

has a side-mounted parallax adjustment knob. The windage adjustment is underneath a traditional screw-on cap, but the elevation adjustment features a large knob with clearly marked increments so you can dial up for distant targets. However, I like the clearly identifiable graduations on the crosshair, too. The lower vertical wire is numbered in 4 MOA increments, while the right horizontal wire is marked in 8 MOA increments, so ‘counting hairs’ is kept to a minimum. Because I grew up adjusting my hold within the parameters of the

reticle, I am very comfortable using a reticle that doesn’t require me to dial a turret. The G2M is a perfect example of one that works for hunters and target shooters alike. Your wind holds are very easy to adjust for using this reticle, and the magnification range is perfect for most hunting scenarios. If you’re looking to play the long-range game, I think this scope warrants a good, long look. It sits on my Legendary Arms Works Professional in .308 Winchester, and works perfectly.

The Bushnell LRHS on the Legendary Arms Works Professional in .308 Winchester.



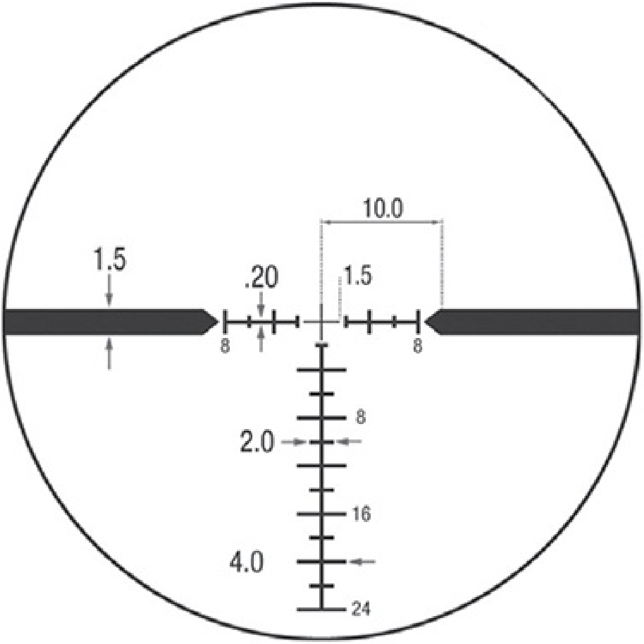
The Swarovski BRX reticle in the Z5 3.5-18x44.

My Swarovski Z5 3.5-18x44P with BRX reticle is another scope that has worked very well for me. It rests atop a Savage Model 116 6.5-284 Norma, and allows me to take full advantage of the attributes of the rifle and cartridge. It is a second focal plane scope, with what many would call a “Christmas Tree” reticle, in that the smaller crosshairs below the main crosshair — used for holdover — get wider as they get lower, to help adjust for the increasing effects of wind deflection as distances and time of flight increase. The scope is actually set

up for milliradians, but a quick conversion isn't too difficult when you need to make a range card. Any good ballistics program will give you the values in distance (inches), milliradians or MOA. This scope also features a side-mounted parallax knob, yet uses the smaller hunter-style turrets; the traditional type under the caps. It's a nice, trim scope, with a one-inch tube, yet the 44mm objective allows in all sorts of light. At its lowest magnification, I've used this scope in the woods for the close shots around home. Yet, I've also cranked

up to 18x magnification to hit steel plates at 1,200 yards. Below the main crosshair there are five lower ones, interspersed by four mil-dots, in an alternating pattern. These are in ½ mil increments, with the dots being 1 mil apart. Each lower bar has a hash mark for wind calls, midway to the end of the bar. Well thought out, the BRX reticle is easy to use once you get a dope card built, and you can easily memorize holds out to 400 yards. Conveniently, the wind adjustment marks are located on the lower horizontal hairs, making for more accurate holds.

The Savage Model 116 in 6.5-284 Norma, topped with the Swarovski Z5.



The Vortex HSR-4 reticle.

I have two dope cards for this scope, one using a 200-yard zero, the other for a 250-yard zero; depending on the hunt, I use both. The fine crosshairs allow for accurate holds, and the focus adjustment lets me make sure the crosshairs are perfectly focused, which can make a huge difference when superimposing the image on targets, especially in mirage and other difficult conditions.

I have a Vortex Razor-HD 3-15x42mm scope, one-inch tube, with the HSR-4 reticle. In addition to crystal clear glass in a nice, lightweight package, the reticle is

concise, yet totally useable. Constructed in a German 3P configuration, the HSR-4 has thicker areas on the ends of the horizontal wires and no vertical wire above the center point. The lower wire has no thickening, but has graduated hash marks in 2 MOA increments. All the graduations are marked numerically, in 8 MOA increments. This type of reticle centers the eye very quickly, and in spite of the lack of conventional crosshairs, feels very natural. I appreciate the center crosshairs, as they are the finest of any in the reticle. For the target shooter who

likes to focus on the smallest part of a paper target, this reticle is absolutely perfect. The Razor uses the traditional hunting turrets, at ¼ MOA per click. I’m quite OK with that, as the HSR-4 reticle is detailed enough to allow me to holdover without having to worry about dialing. Vortex has a great package here, offering plenty of magnification and a very useable reticle. Plus it’s a concise profile that won’t adversely affect the balance of your rifle.

The author is comfortable using this Heym Express with Leupold 2.5x Compact scope on game out to 250 yards. It’s simple, and it works.

The Leupold VX6 2-12x40mm scope on a Winchester Model 70 Classic Stainless in .300 Winchester Magnum.

Many of my other riflescopes use the duplex reticle. My Leupold VX-6 2-12x44 is as clear as any I’ve ever used,

and while it has a plain but crisp duplex reticle, precise holdover can be an issue. I use this scope on my Winchester Model 70 Classic Stainless in .300 Winchester Magnum, which I keep zeroed at 250 yards. In spite of the fact that there is no real measuring system on the reticle (I don’t really use this rifle for a target gun) it’s one of my main hunting rifles. I can hold dead on to about 275 yards and, on most game animals I hunt, have a very good idea how to adjust the hold based on the size of the animal. Keep in mind, I’m not really comfortable with shots

much past 400 yards at unwounded game, so there isn’t a huge amount of thought needed, as it’s a pretty flat shooter.

My Heym .404 Jeffery wears a Leupold Compact 2.5x fixed power scope, with a duplex reticle, and the adjustments in one-MOA visual increments (no clicks). Though it’s only 2.5x, I’ve used this little optic to hit steel plates out to 275 yards. I am pretty comfortable using this rig on big game out to 250 yards, as I’ve spent a considerable amount of time with it. Point being that there are many different

reticles available, each and every one has a specific application.

THE DIAL-UP METHOD

Modern scopes, when mated with a good dope card or ballistic computer, can easily be used to hit targets at longer ranges by ‘dialing-up’ a specific amount of elevation, and using the center crosshairs to precisely place the shot on the target. The process is relatively simple, though it may seem foreign at first. Zero your rifle at a prescribed distance — we’ll use 100 yards for our example — and adjust the elevation turret

for the proper hold for shots at any farther distance. The amount of adjustment necessary will need to be recorded; this is the ‘dope card’ that so many shooters carry, and sometimes you’ll even see it taped to the side of the rifle. I like to have the chart indicate the necessary holds at 50 yard increments so I can interpolate the curve for anything in between those reference points. The good folks at the FTW Ranch provide a common sense card that is well laid out and gives me the necessary information for both the dial-up method, as well as

the ability to properly correlate my reticle to my trajectory curve if I decide to hold over instead of dial. You can set the elevation and windage turrets to read ‘zero’ when you’re properly sighted in, and no matter what adjustments you make during the course of your shooting session, you can always return your scope to that 100-yard zero. The same can be said for wind adjustments. If you want to dial your wind hold, a good, clearly marked turret will allow you to make adjustments and return to your ‘no wind’ zero.

Weaver and Swarovski now have a ‘hybrid’ system, which I think will make a great compromise for hunters who appreciate the dial-up technique and the ability to always shoot the center crosshair, but don’t want to carry charts or dope cards. It works in similar fashion to a bow sight, in that a series of color-coded markers are installed on the elevation turret, and once the distance to the target or animal is confirmed, the correlative color marker is dialed for the shot. It’s a relatively simple, quick system, one I find works perfectly on a

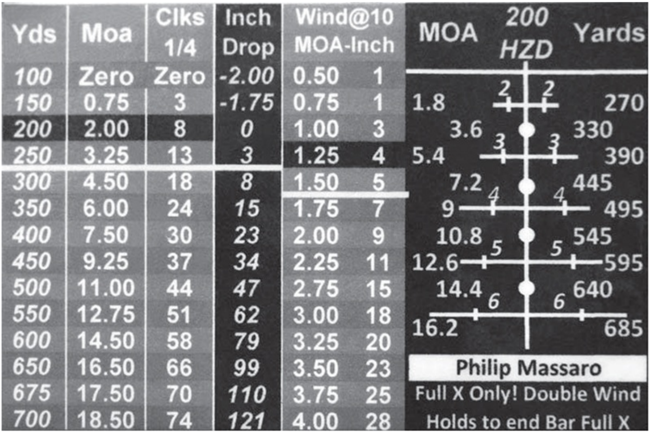
hunting rifle. Combined with a good rangefinder and some time at the target range to verify where your chosen load is hitting — preferably out to 400 yards — you can set one color for each 100-yard increment and interpolate for shots in between. Genius move!

There are even scopes with dial-up turrets designed for rimfire rifles. Bushnell's Rimfire Optics line includes a nice 3-9x40mm scope that comes with a pair of trajectory-compensated turrets. These best approximate the trajectory curve of the .22 Long Rifle and .17

Hornady Magnum Rimfire cartridges. The .22 Long Rifle turret is marked in yardage increments, from 75 yards — a popular zero setting for this cartridge — out to just about 175 yards. The turret dial is numerically marked in 25-yard increments, with interspersing hash marks for precise shooting in between those distances. My pal Manny Vermilyea and I put this system to the test at our backyard range, and I'm happy to report that it worked as advertised. Our test rifle was a Savage Mark II BRJ, actually a very accurate bolt gun that

belongs to my wife Suzie, and after setting zero at the prescribed 75 yards we engaged a series of plates, paper targets and other metallic doodads from 50 out to 200 yards. A laser rangefinder verified the distance, the Bushnell scope tracked perfectly, and all hits were well within the margin of accuracy that the ammunition provided. At 9x, this rig would definitely take squirrels and rabbits out to 100 yards, maybe more, making for a fun little rifle that will change the rules of small game hunting. You may have to make minor

adjustments if you're shooting the hyper-velocity .22 LR ammo, but the calibration worked perfectly for the standard loads.



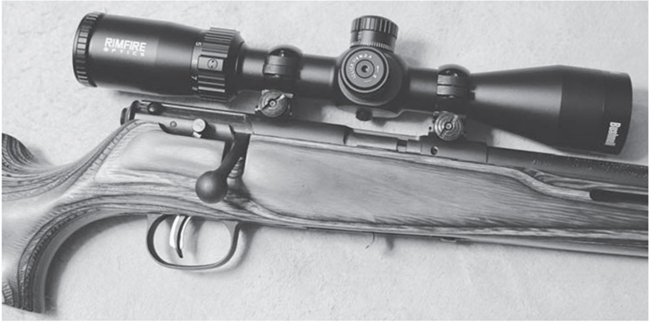
Yds	Moa	Clks 1/4	Inch Drop	Wind@10 MOA-Inch	
100	Zero	Zero	-2.00	0.50	1
150	0.75	3	-1.75	0.75	1
200	2.00	8	0	1.00	3
250	3.25	13	3	1.25	4
300	4.50	18	8	1.50	5
350	6.00	24	15	1.75	7
400	7.50	30	23	2.00	9
450	9.25	37	34	2.25	11
500	11.00	44	47	2.75	15
550	12.75	51	62	3.00	18
600	14.50	58	79	3.25	20
650	16.50	66	99	3.50	23
675	17.50	70	110	3.75	25
700	18.50	74	121	4.00	28

The FTW range card — detailed enough for any use, but easy to read and understand.

The .17 Hornady Magnum Rimfire turret takes advantage of the cartridge's higher velocity and flatter trajectory, giving you the opportunity to accurately dial up for ranges from 25 out to 275 yards. It's the same procedure as the .22 LR, as it maintains the same ¼ MOA shift per click value, but you'll easily see how the flatter trajectory requires much less adjustment for the faster cartridge as well as offering the capability to make hits at longer distances than will the .22 Long Rifle. Bushnell also provides a third turret, marked in ¼ MOA increments.

That gives you a total 15 MOA of adjustment in one revolution for use of different cartridges, and to prepare your own dope chart.

Mandrake Vermilyea working the turret on the Bushnell Rimfire scope.



The Bushnell Rimfire Scope, atop a Savage Mark II BRJ.

This scope also comes with the all-important parallax adjustment knob, keeping distant targets perfectly focused. As a side note, this type of scope on a .22 Long Rifle makes for an excellent practice tool for sharpening your skills;

there in no recoil and little report, and you can easily turn a 100-yard backyard range into a miniature long-range situation, strategically placing spinner targets or scaled-down plates at various ranges. Think mini-golf for shooters!

I opted for a rimfire scope with the BDC reticle for my own .22 Long Rifle, a Bushnell A22 scope with three mil-dots on the lower post. When my rifle is zeroed for 50 yards, the three lower dots give me aiming points for 75, 100 and 125 yards. While this system is not as refined as Suzie’s, it sure makes hits past

50 yards much easier than guesstimating with a traditional duplex reticle. Bushnell also provides a turret with markings for 50, 75, 100 and 125 yards, if I were to choose to dial up, but I don’t use it often; actually I installed it to check if it worked, and haven’t touched it since. I guess I’m just not a dialer. This scope is built with an adjustable objective lens, the adjustment ring being on the end of the scope so I can focus clearly on those gray squirrels way up in the oak trees.

Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	ComeUp (MOA)	Wind Drift (in.)	Wind Drift (MOA)	Spin Drift (in.)	Spin Drift (MOA)	TOF (sec.)
0	2,580	2,070	-1.75	0	0	0	0	0	0
25	2,545	2,015	-0.2893	-1.1052	0.0348	0.1329	-0.0027	-0.0102	0.0293
50	2,511	1,961	0.8337	1.5923	0.1396	0.2666	-0.0108	-0.0206	0.0589
75	2,477	1,908	1.6128	2.0536	0.3158	0.4021	-0.0246	-0.0313	0.089
100	2,443	1,857	2.0384	1.9467	0.5649	0.5395	-0.0441	-0.0421	0.1195
125	2,410	1,806	2.1003	1.6046	0.8886	0.6789	-0.0696	-0.0532	0.1504
150	2,376	1,756	1.7875	1.1381	1.2887	0.8205	-0.1013	-0.0645	0.1817
175	2,343	1,707	1.0913	0.5955	1.7665	0.964	-0.1392	-0.076	0.2135
200	2,310	1,660	0	0	2.3239	1.1097	-0.1837	-0.0877	0.2458
225	2,277	1,613	-1.4988	-0.6362	2.9628	1.2575	-0.2347	-0.0996	0.2785
250	2,245	1,567	-3.4157	-1.3048	3.6849	1.4076	-0.2927	-0.1118	0.3116
275	2,212	1,522	-5.7625	-2.0012	4.4918	1.5599	-0.3577	-0.1242	0.3453
300	2,180	1,478	-8.5537	-2.7229	5.386	1.7145	-0.4299	-0.1369	0.3794
325	2,148	1,435	-11.8016	-3.4678	6.3697	1.8717	-0.5097	-0.1498	0.4141
350	2,116	1,392	-15.5195	-4.2346	7.445	2.0314	-0.5971	-0.1629	0.4493
375	2,084	1,351	-19.7216	-5.0224	8.6144	2.1938	-0.6924	-0.1763	0.485
400	2,052	1,310	-24.4248	-5.8314	9.8806	2.359	-0.7958	-0.19	0.5213
425	2,021	1,270	-29.6425	-6.6609	11.2458	2.527	-0.9076	-0.2039	0.5581
450	1,990	1,231	-35.3907	-7.5107	12.7126	2.6979	-1.0279	-0.2181	0.5955
475	1,958	1,193	-41.6884	-8.3816	14.284	2.8718	-1.1572	-0.2327	0.6335
500	1,927	1,155	-48.5516	-9.2734	15.9625	3.0488	-1.2956	-0.2475	0.6721
525	1,896	1,118	-55.9986	-10.1864	17.7517	3.2291	-1.4434	-0.2626	0.7113
550	1,865	1,081	-64.0494	-11.1213	19.6555	3.4129	-1.6008	-0.278	0.7512
575	1,834	1,046	-72.7245	-12.0786	21.678	3.6004	-1.7681	-0.2937	0.7918
600	1,802	1,010	-82.0449	-13.0589	23.8232	3.7919	-1.9455	-0.3097	0.833
625	1,771	975	-92.0322	-14.0626	26.0954	3.9874	-2.1333	-0.326	0.875
650	1,740	941	-102.714	-15.0911	28.4996	4.1873	-2.3319	-0.3426	0.9177
675	1,709	908	-114.111	-16.1446	31.0398	4.3916	-2.5414	-0.3596	0.9612
700	1,677	875	-126.251	-17.2243	33.721	4.6005	-2.7623	-0.3769	1.0055

View a text version of this table

Using a good ballistics calculator, many of which can be found on the ammunition company’s websites, you can find the trajectory data for your given load in MOA, mils and inches. If you

know the distance between the graduations on your reticle, you can easily correlate the values and establish where on the trajectory curve those graduations will cross. For example, using the Hornady 4DOF (4 Degrees of Freedom) Ballistics Calculator, I plugged the following data into the program.

Bullet: 140-grain Hornady ELD-Match, G1 BC of 0.610

Muzzle Velocity: 2,580 fps (low for this cartridge, but where the accuracy lies)

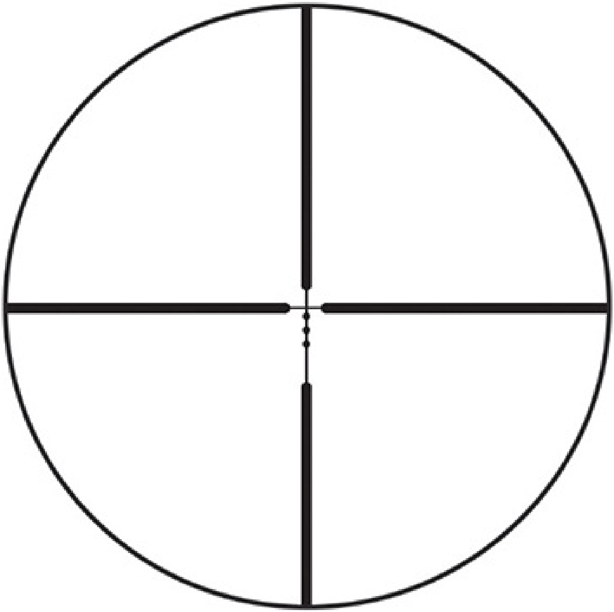
Zero Range: 200 Yards

Wind speed/angle: 10mph, 90 degrees

This is the information that 4DOF spit back at me:

This is good information, providing you with anything you could want for accurate long-range shooting. The Swarovski riflescope I have on this rifle uses the BRX reticle, with lower graduations in 1.8 MOA increments, so I’d need to interpolate to figure out where those graduations will strike along the trajectory curve, telling me where to hold in the field. Doing some math, I came up with much the same info as did the folks

down at FTW, as described in chapter 8. You can do the same thing for your rifle/cartridge/scope reticle combination, using a ballistic calculator and some interpolation. The nice thing about these programs, and other means I’ll describe here shortly, is that they give all the data necessary to compute trajectories for either holding over with a BDC reticle, or for dialing.



The Bushnell BDC reticle with holdover marks for 75, 100 and 125 yards.

I know many hunters who prefer the dial-up technique but I feel more comfortable using a BDC reticle; it goes to show that there is more than one way to skin a cat, and no matter which method you choose — so long as it allows you to become a more accurate shot — is fine.

MEASURING MUZZLE VELOCITY

An important factor in predicting trajectory curves and wind deflection values is the muzzle velocity of the projectile. Almost all of today's ammunition comes with the proposed

muzzle velocity clearly marked on the box, but I’ve seen that value be off by a considerable amount, sometimes 100 fps or more. If you handload, muzzle speeds are listed in the reloading manual for each powder charge weight, but just like the factory ammunition those values can be affected by barrel length, construction, and other factors. If you intend to play the long-range game and invest in proper bullets, optics, and triggers, you absolutely need to know what the muzzle velocity of your load is in order to establish a valid trajectory curve. A

chronograph is the tool you need for measuring muzzle velocity of any projectile, whether it be fired from handgun, rifle, muzzleloader, or bow. Knowing how to use one will save you tons of ammunition and time. Modern chronographs utilize a series of sensors to measure the time of flight of the projectile as triggered by the shadow of the bullet passing over them. The chronograph needs at least two sensors to measure the time difference between the crossing, and establishing the velocity of the projectile.

Bushnell’s BDC rimfire scope on the Ruger 77/22.

The Competition Electronics chronograph that met its untimely demise at the hands of a .505 Gibbs.

Like all kinds of gear, there are worthy chronographs, and unworthy ones. I’ve had both, and a chronograph is like a riflescope: buy the best you can afford. I had a Competition Electronics ProChrono Digital machine that served me well for a number of years until one day when the muzzle blast of a .505 Gibbs kind of scrambled its brains. It was an accurate machine, but it didn’t like muzzle brakes, which would cause inaccurate readings. One fateful day, when I put it out in front of the big elephant gun, well, that was the end. I tried a couple of similarly priced

models, all having two screens, when I found what I consider to be the best balance of affordability, value, and accuracy, the Holy Grail of chronographs: the Oehler Model 35P. This rig uses three sensors and three skyscreens, and has long cables to connect the sensors to the readout unit so the electronics aren't exposed to the muzzle blast. The three screen setup works like this: placed at two-foot intervals, the sensors measure the time of bullet flight between sensors one and two and then again between sensors one and

three, averaging the results. The 35P comes with an onboard printer, which is a nice way to keep records of your various loads’ velocities, and to pay attention to your shooting instead of worrying about recording the velocities by hand.

The Oehler Chronograph, set up for work.

The Oehler 35P chronograph.

Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	ComeUp (MOA)	Wind Drift (in.)	Wind Drift (MOA)	Spin Drift (in.)	Spin Drift (MOA)	TOF (sec.)
0	2,680	2,234	-1.75	0	0	0	0	0	0
25	2,645	2,175	-0.3822	-1.4601	0.0332	0.1267	-0.0025	-0.0096	0.0282
50	2,609	2,118	0.6735	1.2863	0.1327	0.2535	-0.0101	-0.0193	0.0567
75	2,575	2,061	1.4109	1.7966	0.3	0.382	-0.023	-0.0292	0.0857
100	2,540	2,007	1.8209	1.739	0.5363	0.5121	-0.0413	-0.0394	0.115
125	2,506	1,953	1.8938	1.4469	0.843	0.6441	-0.0652	-0.0498	0.1447
150	2,472	1,900	1.6214	1.0323	1.2213	0.7776	-0.095	-0.0605	0.1748
175	2,438	1,849	0.9934	0.5421	1.6729	0.9129	-0.1308	-0.0714	0.2054
200	2,405	1,798	0	0	2.1994	1.0502	-0.1727	-0.0825	0.2364
225	2,371	1,748	-1.3684	-0.5808	2.8022	1.1894	-0.221	-0.0938	0.2678
250	2,338	1,700	-3.1218	-1.1925	3.4831	1.3305	-0.2757	-0.1053	0.2996
275	2,305	1,652	-5.2739	-1.8315	4.2441	1.4739	-0.3371	-0.1171	0.332
300	2,272	1,606	-7.8327	-2.4934	5.0865	1.6192	-0.4054	-0.1291	0.3647
325	2,240	1,560	-10.8137	-3.1776	6.0127	1.7668	-0.4808	-0.1413	0.398
350	2,207	1,515	-14.2264	-3.8818	7.0241	1.9166	-0.5635	-0.1538	0.4317
375	2,175	1,471	-18.0842	-4.6054	8.1228	2.0686	-0.6537	-0.1665	0.4659
400	2,143	1,428	-22.4008	-5.3482	9.3114	2.2231	-0.7516	-0.1794	0.5007
425	2,111	1,386	-27.1904	-6.1098	10.5922	2.3801	-0.8574	-0.1927	0.5359
450	2,079	1,344	-32.4671	-6.8902	11.9675	2.5398	-0.9713	-0.2061	0.5717
475	2,048	1,304	-38.2454	-7.6893	13.4397	2.7021	-1.0937	-0.2199	0.6081
500	2,016	1,264	-44.5402	-8.5072	15.0112	2.8671	-1.2246	-0.2339	0.645
525	1,985	1,225	-51.3712	-9.3447	16.6853	3.0351	-1.3645	-0.2482	0.6825
550	1,953	1,187	-58.7512	-10.2014	18.4638	3.206	-1.5135	-0.2628	0.7206
575	1,922	1,149	-66.7006	-11.0781	20.3502	3.3799	-1.672	-0.2777	0.7593
600	1,891	1,112	-75.2375	-11.9753	22.3479	3.557	-1.8401	-0.2929	0.7986
625	1,860	1,076	-84.3807	-12.8934	24.4608	3.7376	-2.0182	-0.3084	0.8386
650	1,829	1,040	-94.1508	-13.833	26.693	3.9218	-2.2065	-0.3242	0.8793
675	1,797	1,005	-104.57	-14.7948	29.0486	4.1098	-2.4052	-0.3403	0.9206
700	1,766	970	-115.662	-15.7796	31.5323	4.3019	-2.6147	-0.3567	0.9627

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Muzzle velocity most definitely needs to be ascertained for long-range shooting. Comparing the dope from the example given above, and changing muzzle velocity by exactly 100 fps from 2,580 to

2,680, you’ll see that the long-range drop changes significantly.

At the 700-yard mark, the drop is off by 10 inches, enough to cause all sorts of issues. While the ‘hunting’ dope doesn’t radically change things inside 400 yards, considering the size of a big game animal’s vital area I can see where the long-range crowd would be highly concerned about having an accurate muzzle velocity. Find a chronograph within your budget, and make it your friend.

One last piece of advice: always be cognizant of the placement of your chronograph. I’ve see them blown to bits by shooters who forgot their scope is placed 1.75 inches above the bore line, and I’ve seen units totally smashed by the plastic sabots of muzzleloading rifles. Many times the skyscreens and their metal support rods can be replaced easily enough, but if your chronograph has internal electronics, it may be headed for the recycle bin if it takes a direct hit.

RANGEFINDERS, WEATHER STATIONS AND HANDHELD BALLISTIC DEVICES

As a shooter, I like all the gadgets and gizmos associated with it, but I always do my best to make sure I can still make things work when the batteries die, if you will. Dope charts, memorization, preparation; I try to keep things as free from an electronic error as possible. I do carry a rangefinder, as it's become a huge aid in establishing the proper hold for the specific range, rather than trying to guess.

However, as we learned in the density altitude section (chapter 11), the surrounding weather conditions can also affect your bullet’s flight path, so if you can develop an adjusted dope chart for changing environments, it’d be a no-brainer to include a device that will do just that in your hunting pack. If I had to limit my electronics to just two pieces, they’d be a good laser rangefinder capable of measuring out to 1,000 yards and a quality ballistic device. I’ve used different models, but have settled on a

pair that sealed the deal for me. First, the rangefinders.

RANGEFINDERS

Knowing the distance to your target is imperative. Just a quick glance at the chart shown for my 6.5-284 Norma will show you that the drop between 400 and 450 yards is over 11 inches. That’s more than enough to cause a missed plate or shoot underneath a game animal, not to mention a missed wind deflection hold. I’ve told you before that I am a licensed land surveyor, and measuring distances is what we do in the field. My Dad and I are

partners, and play the same ‘how-far-do-you-think-that-is’ game every day, and then we measure the distance with a Geodetic Total Station, down to 1/16 of an inch. 30 years of playing this game has proved to me that I can routinely be wrong by at least 50 yards, especially when distances become greater than 300 yards. Since beyond that range is where knowing the distance really becomes crucial, visual range estimation amounts to just a guess, at best.

The Bushnell 1 Mile ConX rangefinder, which conveniently interfaces with the Kestrel Elite.

Using a laser rangefinder is a great method of getting closer to the truth. Yes, in a perfect world, there would be no obstructions between you and your game

animal, and that animal would pose statue still as if being photographed for the cover shot of a magazine. However, I’m sure you understand that this isn’t always the case, and that you may need to range a tree nearby the animal, or a mound in front of or behind said animal. Owning a laser rangefinder that works well in a number of different light and vegetation conditions makes a whole lot of sense. I like the Bushnell rangefinders; we’ve used them on the job for decades to measure streams, hedgerows and other features that don’t require a ridiculous

level of surveying precision and they’ve been rock solid. We test them often for dependability as well as for fun, measuring distances in comparison to our survey transit, and they’ve been very accurate. The older models were simple, just offering the measured distance between the unit and the target, irrespective of slope angle. They have come an awful long way since those days, with many useful features that will aid in making the shot. I have a Bushnell Elite 1Mile ARC ConX, which is much more than just a measuring device. This

tool establishes slope and level distances — both useful for establishing wind calls and trajectory drop, respectively — out to one mile. It will interface with a Kestrel Elite ballistic computer (we’ll discuss that awesome tool below), relaying the information observed to the ballistic computer, and then receiving data from the computer and displaying it within the rangefinder. Pretty sweet deal, especially for the solo hunter, or the target shooter who doesn’t have a spotter. I’ve checked the accuracy of this unit for both measurement of distance and slope angle

against a surveying instrument, and it’s surprisingly good, holding measurements of distance to within a yard, and angle to within a degree. It’s not the most affordable model on the market, but if that sheep of a lifetime is 400-and-something yards up the steep scree slope, the cost of the unit is well worth knowing the exact distance. It features 7x magnification and even works well in the rain, which is where some other rangefinders have failed me. There are similar models that don’t have Bluetooth connectivity that are a bit more

affordable, but use the same measuring systems for those who don’t wish to use the Kestrel computer.

ANEMOMETERS AND BALLISTIC COMPUTERS

The Kestrel Elite 5700 Weather Meter with Applied Ballistics is a God-send to the long range shooter, global hunter, or serious competitive shooter. It is, at the same time, an Anemometer or, weather meter — giving complete weather data at your location — with a built-in ballistics computer. The Kestrel Elite utilizes the highly powerful Applied Ballistics

software, developed by Bryan Litz, an Aerospace Engineer who is perhaps one of the greatest living ballisticians, and a man for whom I have great respect. Litz now heads up research for Berger Bullets, as well as Applied Ballistic Munitions, the factory loaded ammunition featuring Berger projectiles. Using a Kestrel Elite is relatively simple. With the information provided in this book, the possible parameters needed for input into the Kestrel, you can build a trajectory curve for your particular firearm and have it adjust for a change in location and

elevation. Spin drift, Coriolis, trajectory, even wind deflection can be calculated quickly and accurately. It has several popular long-range cartridges and their parameters pre-loaded, plus the capability of loading the parameters of your chosen bullet, in both G1 and G7 drag models.

This handheld wonder can even compute custom drag curves for bullets that have a ‘sketchy’ BC value, ones needing to be redefined with a curve that works. The power of this unit needs to be seen in order to be truly appreciated. I’ve used it for days on end in the field,

shooting at targets from 100 to 1,400 yards, in changing weather conditions. The FTW Ranch in Texas has a variety of terrain, and the weather can change from cool in the mornings to blazing hot and windy by late afternoon. The Kestrel adjusted the trajectory curve for my rifle, based on the changing weather conditions, as well as being a huge aid in making wind calls. You see, the weather station side of the device observes magnetic bearing (necessary for adjusting the Coriolis Effect), wind speed, temperature, chill factor, humidity, heat

index, dew point, a wet bulb reading, barometric pressure, altitude, and density altitude. Wind direction is also measured to correlate the amount of the wind value that should be taken, in comparison to the direction of the target. You can include a couple of baseline wind values, for comparison to the actual wind speeds observed along the bullet’s flight path.

The Kestrel Elite computer/weather station will greatly aid the shooter in projecting trajectory and wind drift.

You can ‘build’ your rifle, or several rifles, or several loads, which will be stored in the unit. The whole shebang runs on a single AA battery, securely

housed in its own compartment so that the electronics are safe should a battery leak. There is a battery meter displayed when the unit is powered up that keeps an eye on power levels during the course of a hunt. The Kestrel allows you to input data in metric or English units, and has the choice of several different output units, such as true MOA or ‘shooter’ MOA (rounded off a bit), clicks, or mils. It isn’t hard to modify the trajectory curve to match the observed field data. You can calibrate the muzzle velocity of your rifle by feeding the device the

observed amount of drop in inches, true MOA, or mils at a certain distance, so that the drag curve may be adjusted properly. This process is generally known as ‘truing’ a rifle, and the further away from the muzzle you can observe repeatable data, the more accurate your results will be.

Keeping this idea in mind, we put the Kestrel to the test at the FTW. Dave Fulson of Safari Classics Productions and I were spotting for Nate Lee, a talented young shooter who knew his 6.5 Creedmoor very well. We had observed

the muzzle velocity of the Hornady Match ammo Lee was using, and the FTW staff had plugged all the parameters into their ballistic computer program to develop a dope card for him. However, getting out to 900 yards or so, we noticed that the drop figure (in minutes) was off. An extra 1.25 minutes was needed to center-punch the plate. Instructor Doug ‘Dog’ Pritchard and I simply built the rifle profile in the Kestrel Elite, and fed it the revised hold at 900 yards. The electronic wonder adjusted the trajectory on the fly for the new data, and revised

the curve. Lee rang the 1,400-yard steel plates without much trouble at all.

Where I can see that the Kestrel will truly show its worth is in the hands of the traveling sportsman. Atmospheric conditions are much different when hunting elk at 9,000 feet in Wyoming than they are hunting deer on the shores of the Hudson River, at 50 feet above mean sea level. Likewise, things change when hunting in the hot, dry conditions of South Africa in comparison to the wet, cold forests of New Hampshire. A device like the Kestrel Elite adjusts for these

changes in elevation and atmospheric condition, keeping you informed of the changes in your rifle’s performance. It may just help you bag the trophy of a lifetime. My Elite has the LiNK feature, which allows it to Bluetooth connect with my Bushnell ConX rangefinder. That way, the unit can stay by my side, feeding the holdover data directly into the display of the rangefinder. Simply click the rangefinder and you’ll see the hold in the units of your choosing. This combination makes for a slick setup in the field,

whether you want to ring steel, or hit that prairie dog out there at 400 yards.

With a spotter, ranges and holdover values are easily established.

Essentially, if you have the means of accurately measuring bullet length, twist rate, and muzzle velocity, you can arrive at all of the data I’ve explained in equation form by using the Kestrel Elite, and you can do it on the go, in any condition, at any feasible range. Hell, for those who really want to take shots at extreme ranges, the Kestrel even has the ability to create a custom trajectory curve for a bullet once it goes into the trans-sonic and subsonic phases, where things can get truly weird.


SIERRA
The Bulletsmiths®
TIPPED MatchKing®
30 CAL .308 DIA.
168 GR. TMK
100 RIFLE BULLETS
1.358 in
mm in
ON OFF

A good set of dial calipers will quickly become your friend.

ONLINE BALLISTIC CALCULATORS

The Kestrel Elite is a wonderful tool, and well worth the financial investment, but I know there have been times in my life where the budget simply would not allow for a purchase of this magnitude — the wife would've skinned me alive. So, you can 'adapt and overcome' by preparing your own dope cards and charts based upon some of the excellent ballistic calculators available for free online. I've

mentioned the Berger Twist Rate Calculator, to make sure your bullet is stable in flight, and I’ve demonstrated how the Hornady 4 Degrees of Freedom program can give you some really good data, but they’re not the only ones. Federal and Winchester have their own programs, too. In addition to the bullet and ammunition companies, the optics companies offer excellent programs as well. I like the Vortex site, as it allows you to save your load profiles.

In my opinion, the more data you are allowed to input, the better the data

coming back out will be. Hornady's 4 Degrees of Freedom uses the drag coefficient for a particular bullet, rather than the G1 or G7 model comparisons, and that may result in some different data. I've found it to be rather accurate, especially when using the Hornady bullets available in the program, or the other popular long-range projectiles involved in this new offering.

The Federal program has settings for all of their factory ammo, but with the ability to change the curve based upon your observed muzzle velocity. This a

great feature if you’re shooting factory ammo but want better dope than what is available from a generalized muzzle velocity. Simply run your Federal ammunition through a chronograph, and apply the revised muzzle velocity to generate a customized dope chart for your gun.

If you have a smartphone, there are quite a few ballistic apps available for download, at a minimal cost, if not free. Winchester has their ballistic calculator as a free app for the iPhone and iPad, and the Strelok calculator is an affordable

option for a smartphone. Here's a list of some cool sites and apps, by no means complete. A quick Internet search will yield a whole bunch from which to choose, but these are the ones I've used over time.

www.hornady.com/ballistics-resource/4dof

www.bergerbullets.com/ballistics/

www.federalpremium.com/ballistics_ca

www.appszoom.com/android_applicati

play.google.com/store/apps/details?id=com.borisov.strelok&hl=en

www.winchester.com/learning-center/ballistics-calculator/Pages/ballistics-calculator-iphone.aspx

TRIGGERS

Without getting into a dissertation on gunsmithing, I can tell you that a great rifle can easily be ruined by having a lousy trigger on board. I am not a light trigger freak. But a trigger that breaks at over five pounds can be a severe hindrance to accuracy. I like a trigger to break cleanly, with as little creep and overtravel as possible, so that I can place

my shots in a consistent manner. I’ve had some rifles (that later turned out to be gems) that wouldn’t shoot well at all out of the box, due to heavy trigger pull. Some of the Ruger Model 77 Mk II rifles of the late 90s had terrible, non-adjustable triggers, and I nearly gave up on one such rifle until I switched out the factory trigger for a Timney. What a world of difference that made! My .22-250 went from punching groups of 1 ¼ inches to printing ⅜-inch groups, without touching the load. I don’t mean to sound like I’m beating up on those Ruger rifles

— the newer Hawkeye models have a trigger that is a vast improvement — but I’ve used a trigger scale to measure the pull weight on several of those older models, and some are approaching 10 pounds and even more. That, to me, is unacceptable for any rifle that is expected to deliver accurate results. I have a couple Legendary Arms Works rifles, and that company was wise enough to use Timney triggers right out of the factory. They are an absolute pleasure to shoot.

A Timney replacement trigger about to improve a Ruger tang safety in the Model 77.

The Timney trigger in the Legendary Arms Works gun is a valuable feature.

Timney isn’t the only replacement trigger out there — Jewell, Wilson Combat, Geisselle, there are many, and sometimes a replacement will give a rifle a new lease on life. Though many triggers can be installed with simple

tools, I recommend having a replacement trigger installed by a competent gunsmith to avoid any potential safety issues such as accidental discharges. Your rifle may have an adjustable trigger right out of the factory — the Savage AccuTrigger comes quickly to mind — and you can find good instructional information on the respective manufacturer's websites regarding safe adjustment of trigger pull. If, however, you have any doubts, it is definitely worth the money to have your gunsmith do the work and avoid trouble.

The Savage AccuTrigger is mighty good right out of the box.

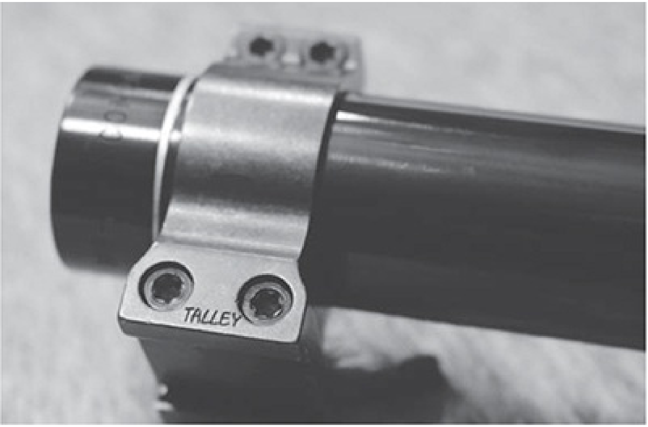
SCOPE RINGS AND BASES

Scope rings and bases are just a simple means of attaching your riflescope to the rifle, but I’ve seen misaligned and improperly installed ones cause all sorts of accuracy issues. For long-range shooting there are bases and rings that provide additional elevation to the riflescope, extending the range of adjustment necessary for those long shots.

You need a rock solid setup when mounting your scope, so that there is no movement whatsoever, and so that you have as much contact as possible between

the scope and the rings so your scope can ‘go to sleep.’ I’ve used a bunch of different brands, and there are plenty of good ones from which to choose. These days, I’m a huge fan of Talley rings, as they are manufactured to very tight tolerances. The design uses the least amount of moving parts. I use the Talley removable rings on my dangerous game rifles, as they can be screwed on and off the rifle. That allows me to use the iron sights on the follow-up of a wounded animal and the scope can then be reinstalled without a zero shift. I also use

the standard Talleys on many of my hunting rifles; my Savage 6.5-284 Norma wears them, as does Suzie’s Legendary Arms Works .375 H&H Magnum.



Talley’s removable rings are perfect for any situation where you need to remove or switch riflescopes.

The Leupold QR mounting system.

I like the Leupold rings and bases, but prefer the dual dovetail to the older-style system that uses two screws to hold the rear ring in place. Too many times I've

had that come loose on a hunt; by contrast, Leupold’s dual dovetail system keeps things right where I put them. My Winchester 70 Classic Stainless in .300 Winchester Magnum has the dual dovetail rings and bases, and the Leupold VX-6 2-12x44 has never moved or lost zero, despite some tough hunts in punishing terrain. I also like Leupold’s Quick Release system, which uses a post to attach the rings to the bases, kept in place via a hemispherical cutout in the post, and a locking lever that rolls a matching piece into that cutout. My

Winchester Model 70 Safari Express in .416 Remington Magnum is equipped with this system, and for years I carried two scopes, pre-zeroed in rings, on safari with me. Should something happen to my primary scope, I could easily remove it and install the backup in the field so the hunt could continue.

The Spuhr +20MOA base gives this .300 Winchester additional elevation capability.

If you are going for distance, you may run out of scope adjustment for those truly long shots. Or you may discover that a scope may not give true

adjustments when at the extreme limits of its adjustment range. There are means of correcting the issue, to make your life a bit easier. A 20 MOA base provides you additional elevation range, as it is tapered to rise toward the rear of the rifle, allowing you to take better advantage of the elevation adjustment of your scope. Warne makes a great 20 MOA base, and there are others; just realize that installing one of these will raise your point of impact by 20 inches at 100 yards, so you may want to make sure your reticle has the option to hold under, using hash

marks on the upper post of the vertical hair, or that the adjustment range of your scope will allow you to dial down that far.

Burris came up with a cool design to solve the problem — their XTR Signature Rings. These use a concentric insert to properly align the scope, resolving some issues with bases that mount slightly off-center, but also are available in 5, 10 and 20 MOA adjustments. Using them there's no need for a tapered base, and the inserts allow

you to achieve combinations of up to 40 MOA of adjustment. Pretty slick idea.

A good spotting scope helps verify hits and group size at the longer ranges.

SPOTTING SCOPES

If you’re serious about long-range shooting, a spotting scope can become

your new best friend. Seeing distant targets is a necessity, and calling shots for a buddy can be almost as much fun as pulling the trigger. Owning a good spotting scope can make your life easier, not to mention saving your legs from having to dance the “off-to-the-target-shuffle.” They generally have much more magnification than do riflescopes, with many popular models topping out at 60x.

You need to measure the wind, especially at the longer ranges, and while a high-magnification riflescope is an excellent aid, a spotting scope can

quickly become an invaluable tool. Seeing mirage is a definite benefit, and the quick adjustments of a spotting scope can help you focus in front of and behind the target in order to make the mirage more visible. As with any optics in the shooting world, the better models are usually pricier, but then again, you get what you pay for. I’ve used several good models from Swarovski, Leupold, Meopta and Bushnell.

I prefer a model with the straight-on rear lens assembly, as opposed to the offset style. I find them easier to aim at

the target. I also like a quick-locking mechanism, to keep the scope where I want it pointed, and a good, strong tripod, preferably height-adjustable for those times I’m shooting alone.

CHAPTER 18
CHOOSING A CARTRIDGE

All the ballistic knowledge in the world won’t help if you don’t choose a cartridge that will deliver what you’re after. And with all the new cartridge developments in the last 20 years, things can get downright confusing. Depending on your hunting or shooting style and location, your choice of cartridge can vary quite a bit. While there are many

‘universal’ choices, you need not try to make a silk purse out of a sow’s ear if you don’t have to.

As both a writer and a handloader, I get many calls and emails regarding the choice of cartridge, and whether some truly deliver what the advertising promises. I’ll address all kinds of centerfires, from rimfire rifles to small, medium and big game calibers, to hunting and defensive handguns. All have a purpose, but it’s ultimately up to you to decide what your needs and

expectations are, and make the choice that best suits you.

To briefly illustrate, let’s say you’re a hunter who sticks close to home, and — like so many of us — pursues game in the deer/hog/coyote class. Would you be best served by a .338 Winchester Magnum? Probably not. While that cartridge will undoubtedly take all of those animals, with power to spare, that level of recoil is not justifiable for those hunting needs.

Federal Ultra Match .22 Long Rifle.

Conversely, if you own a good .270 Winchester, one that has served you well for decades, does that make a sound choice for an Alaskan grizzly bear hunt? Again, probably not, as the grizzly may require a bit more bullet weight and horsepower to end the argument. Yes, it’s

been done before, but the cost of traveling to hunt, in addition to the difficulty of obtaining tags, ought to suggest trying a bigger, more authoritative cartridge.

Do you need a new rifle for an African plains game safari? That'll depend on what you're currently shooting. Does your .25-06 Remington make a good elk gun? Well, while I do know folks who, with very careful bullet placement and the patience to wait for the perfect shot opportunity, do use the .25-06 and similar cartridges for elk, I personally feel there

are better choices, especially for those who may only have a seven-day hunt. If you're planning an elk hunt, I firmly believe that a bigger bore with a bullet heavier than those available in .25 caliber would better outfit you for that big bull elk.

While I'll also touch on the pros and cons of defensive handgun calibers, I'm sure that my arguments won't settle the 9mm Luger vs. .45ACP debate, but I will shed as much light on the topic as I can.

Let's start with the rimfire rifles.

RIMFIRE CARTRIDGES

So many of us learned how to shoot with a good ol’ .22 Long Rifle, that it’s very difficult to count this old-timer out. It’s relatively inexpensive (when available at all!) and so mild in both report and recoil that it remains a solid choice for small game, garden pests and the smaller furbearers. The smaller .22 rimfires — the .22 Short and .22 Long — seem to be fading into obscurity, though in our circle of friends we still have a couple of cool rifles chambered for them.

But what about the other rimfire cartridges? Where do the .17 Mach II, .17

HMR, .22 WMR and .17 WSM fall into the mix, and does their performance warrant the purchase of a new firearm. I had the opportunity to put many of these rimfire cartridges ‘through the ringer’ as they say, on a South Dakota prairie dog hunt. It was with the folks from Vista Outdoors, a huge company that has, under its roof, Federal Premium ammunition, American Eagle ammunition, CCI ammunition, Savage rifles and Bushnell Optics and more, so we weren’t lacking for options. Friend and colleague J.J. Reich had brought a

slew of different rifles, many of them in varying rimfire calibers. We had no shortage of targets, either, as we were situated on some of the biggest prairie dog towns I’ve ever had the privilege to hunt. There were dogs at 50 yards, and dogs at 450 yards, and dogs everywhere in between. The .22 LR handled the close range work as you’d expect, and I even got to stretch it out to 200 yards and beyond. Shots from 200 to 250 yards were not easy in the prairie wind, and I missed more than I hit. While a .22 LR is great for squirrel hunting in the

hardwoods, and for woodchucks in the garden, it didn't exactly make the optimum prairie dog rifle.

The .17 Winchester Super magnum was the bane of the prairie dog town.

The .22 Magnum — with its increased velocity — resisted wind drift a bit more, and flattened out the trajectory, but the blunt nose bullets we had weren't exactly fantastic, either. Now, in all of my experiences with the .22 Magnum, it gave an obvious advantage over the .22 LR with respect to velocity, wind deflection and striking power. But it wasn't a show-stopper in the South Dakota winds. I do like it for hunting coyote and fox here in New York, especially in the woods where the shots are relatively close, say within 100 paces, and where the wind isn't a

huge factor. The .22 Mag will definitely ruin a woodchuck's day as well; but it pales in comparison to any of the .22 centerfires, even the Hornet. If you don't like the report and additional costs of the centerfire small bores, there's absolutely nothing wrong with owning a good .22 WMR; just make sure you practice diligently with it so you'll know exactly what the drop will be on the distant shots. Personally, I really like the CCI V-Max load, which uses a 30-grain polymer-tipped bullet at a muzzle velocity of 2,200 fps; this has proven to be very

accurate in several different rifles,

accounting for many crop-raiding woodchucks and egg-thieving raccoons.

Back to the prairie, and how I made friends with the .17 caliber rimfires. We had the two larger .17s on hand: the .17 Hornady Magnum Rimfire, and the .17 Winchester Super Magnum. I liked both of them, but for different applications. The .17 HMR is the .22 Magnum case necked down to hold .172 bullets, pushing a 17-grainer to 2,550 fps. It’s an accurate little cartridge, perfect for minimizing pelt damage on a furbearer, yet having enough energy to create the

red mist on a prairie dog. The .17 WSM is a whole different ball of wax. Based on a .27-caliber nail gun blank, Winchester set out to develop the fastest rimfire cartridge ever developed, and succeeded. The .17 WSM will drive a 20-grain .17-caliber bullet to a muzzle velocity of 3,000 fps, and this combination works out very well. I used the WSM to take dogs out to 325 yards, even in gusting winds. Just like the fast centerfires, at 3,000 fps the WSM barrel can heat up quickly, especially in a rapid-fire scenario so typical of a prairie dog hunt. However,

if you’re looking for a hot-rodded rimfire, this is your baby.

I’ve spent a bit of time with the .17 Mach II, which is the .22 LR Stinger case though just a bit longer than a standard .22 LR case necked down to .172 caliber. It’s the slowest of the .17 rimfires, driving a 17-grain bullet to a muzzle velocity of 2,100 fps, just a bit ahead of the .22 Magnum, but with less than half the bullet weight. It does offer an advantage over the .22 LR in that the trajectories are flatter. But the light bullet combined with the slower muzzle

velocity falls prey to wind drift. Some shooters love the Mach II, but I personally feel the HMR is a better choice, with its 450 fps velocity gain. None of these rimfire cartridges have enough recoil to bother any shooter, of any stature.

Taking all this into consideration, which of the rimfires suits your needs? I feel every shooter needs a .22 Long Rifle, as they are simply too useful and too much fun to overlook. But if you’re looking for a bit more range, then I’d recommend one of the faster .17s, and I’ll

confess to being enamored with the .17 WSM. Its field performance isn't all that far behind the .17 Hornet (another really cool cartridge), and if you like the rimfire game, you can take this cartridge out farther than any other. I'd like to pair my Ruger 77/22 in .22 LR with a good Savage B-Mag in .17 WSM, to cover all aspects of the rimfire spectrum.

SMALL BORE CENTERFIRES

Centerfire cartridges between .17 caliber and the .25s could be defined as small bore centerfires. These cartridges

fall into two categories: the varmint/small deer class, and the small bore target rifles. Actually, we should split the varmint and antelope/small deer cartridges in two, for three categories. If you’re a varmint or predator hunter, there’s plenty here for you; you’ll see most serious varminters with a rifle in this class. If you prefer to own a rifle that will do double-duty on deer and predators, there are many solid choices within this group, cartridges that can easily wear two hats. And for the target

crowd, this group contains some of the most accurate cartridges ever invented.

The .22 Hornet, while being among the oldest of the .22 centerfires, is still a classic choice.

The .17 Hornet will work perfectly for distant prairie dogs and coyotes alike.

The .243 Winchester can easily do double duty on both predators and deer-sized game.

First, the varmint cartridges. If you want to snipe varmints at distances

measured in football fields, you’ll need some velocity in addition to a frangible bullet. While some of the classic, lower velocity cartridges like the .22 Hornet and .218 Bee are still a ton of fun to shoot, the newer, faster designs make for some serious “reach-out-and-touch-‘em.” Cartridges like the .17 Remington, .204 Ruger, .22-250 Remington and the .220 Swift all launch a bullet over 3,500 fps without much trouble and make great choices for a varmint rig. Although, referring back to the ideas discussed in the chapters about wind deflection and

twist rate, the .22-250 and the Swift have their shortcomings in a traditional barrel. A good .223 Remington still makes a sound choice as a varmint/predator rifle and can, in most instances, handle the longer, heavier bullets that give the advantage in the wind. If you’re looking for something out of the ordinary, a .17 Hornet is a really cool varmint cartridge, pushing a polymer-tipped 20-grain bullet at 3,000 fps. I’ve used this combination to absolutely smoke some prairie dogs and woodchucks. It’s as accurate as it is hard-hitting.

The .257 Weatherby is a big case; too big for all day shooting sessions.

The .243 Winchester makes a good choice if you want a rifle for more than one purpose, as it will work well as a

deer cartridge, but it’s a great varmint cartridge, too. Loaded with lighter bullets, like the Nosler Ballistic Tip 55-grain or a frangible Speer hollowpoint, it makes a great ‘chuck gun, and with some medium weights — like a 75- or 80-grain pill — will absolutely hammer coyotes and foxes. The same can be said for the 6mm Remington and the .243 WSSM: they’re fast, accurate and versatile.

The .22-250 Remington delivers 53-grain hollowpoints very well.

Dr. Louis Palmisano’s 6mm PPC, a benchrest wonder.

Jumping up to the .25 bores, you’ll find that the bullet weights increase, as does recoil. For a long session over a prairie dog town, this much gun may not be the best choice, as even the .250-3000 Savage can wear on you after a long day, let alone a good hammering from the .25-06 Remington or the mighty .257 Weatherby Magnum. If you have a good quarter-bore and you wish to pursue coyotes or other furbearers where the shooting isn’t as hot and heavy (as it

would be over a dog town or a woodchuck field) there's nothing wrong with using it, but I don't know too many varminters who choose cartridges larger than 6mm for long duration shooting sessions.

So what's the thought process? If you'd like to have a dedicated varmint/predator rifle — if you're serious about the little critters — I'd recommend something between the .204 Ruger and the .22-250 Remington, depending on your location and quarry. Faster cartridges make longer shots easier, but

will heat up a barrel during all day shoots, and lead to throat erosion. Bullet weight isn’t necessarily a huge consideration for the terminal phase of things, as animals in this class tend to be smaller and thin-skinned, but considering the wind conditions and distances, the heavier bullets (with higher BC values) will make it easier to connect in difficult conditions. My own favorite rifle for this work is a Ruger Model 77 MkII in .22-250 Remington. It sports a Hogue Overmolded stock, and is topped with a Leupold Vari-X III 6.5-20x44mm scope.

Although it has the 1:12 twist rate — limiting the rifle to 55-grain bullets or lighter — I can take coyotes out to 400 yards, and my handloaded ammunition maintains sub-MOA accuracy out to those distances. My buddy Donnie Thorne swears by his Remington 700 in .17 Remington, and though the bullets generally weigh between 20 and 30 grains, they are moving at over 4,000 fps. I’ve seen him absolutely flatten coyotes, even the big-bodied males we have here in the Northeast. Assess your hunting situation, as well as your intended use,

and you’ll come up with what’s right for you.

Switching gears to the cartridges that you’ll want to serve as deer/antelope medicine — in addition to performing adequately on the furbearers — you’ll want to look at the 6mm cartridges and larger, as they have enough throw weight to handle larger game. This is where cartridges like the .243 Winchester, 6mm Remington, .25-06 Remington, .257 Roberts and .257 Weatherby Magnum truly shine. They are light enough in the recoil department (when compared to the

.300 Magnums) yet heavy enough to effectively handle whitetails, pronghorn antelope, or the light African plains game species. Looking back to the wind deflection values, you’ll see that they aren’t quite as effective as their larger siblings, but still can get the job done in the field, especially within responsible hunting ranges. As I’ve said, they can be loaded with light-for-caliber bullets for use on varmints and predators, but earn their keep in the lighter big game department, too.

I don’t like using .22 centerfires for deer or antelope, as they are a bit light in the bullet weight department, unless you’re using one of the heavy-for-caliber premium bullets, and by that I mean something over 60 or 65 grains, and even those need to be very carefully placed. I know, many disagree with that statement, but I’ve seen deer lost — even the small-bodied ones in Texas — following a good shot from light .22 caliber bullets that either broke up prematurely or simply failed to penetrate. I much prefer the .243 Winchester as a minimum for deer; it hits

with much more authority, and is more forgiving on a marginal shot.

For target shooters, there are some cartridges in .22 and 6mm that have shattered records. Lou Palmisano’s 6mm PPC and .22 PPC, based on the obscure .220 Russian cartridge, produce ‘one ragged hole’ groups, as does the 6mmBR Remington and 6mmBR Norma. These short, fat cartridges don’t have a whole ton of recoil, but are ridiculously accurate. Matter of fact, the 6mm PPC cartridge was recently used by Jim Carmichael to break the record group size

for Light Varmint category in Benchrest competition. If I was after a serious small bore target rifle, I’d look to one of these four cartridges.

In addition, the .223 Remington (as well as the 5.56mm NATO), .222 Remington and the .22-250 Remington make excellent target cartridges. While designed for other purposes (namely hunting or military use), they can and will deliver superb accuracy in a well-tuned rifle using match-grade ammunition.

The .223 Remington and 69-grain Hornady Match bullets are a great choice for target shooting.

The .300 Winchester Magnum, it really can do just about everything.

MEDIUM BORE CENTERFIRES

Medium bore centerfire cartridges are the most common group, being used for

most of our popular big game hunting. Even on an African safari, you’ll probably end up spending more time with a medium rifle in your hand than your big bore, unless you’re on a dedicated hunt for elephant or buffalo. Here I include cartridges ranging from 6.5mm to .358-inch diameter. When things get larger than that you’re into the big bores, though as you’ll see there will be some crossover.

If any group of cartridges has benefitted from modern bullet technology, it is this group, and that’s a

good thing. It is guns chambered in cartridges representing this middle group of which we ask the most — be it a deer rifle, a long-range sheep gun, bear stopper, or target platform. There are quite a few choices, and your hunting style may require more than one of these. All of mine have a purpose, and get used regularly.

Within this category there are just a few ‘universal’ answers to a variety of questions. There are also some age-old debates that still rage on, and probably won’t be resolved anytime soon, as well

as a plethora of new cartridges that have come into the mix. The choice of a cartridge in this category is going to depend on exactly what you’re going to ask it to do for you. Is it a deer rifle, which will only see a few days in the field each year? Or is it a rifle you want to cover a multitude of species, in different environments? Exactly which species do you intend to hunt? Like I’ve said, there are some universal answers, and opinions differ.

Same can be said for target cartridges, in that the application will most definitely

influence the choice. In addition, availability and expense of ammunition will play into the decision-making process. The ballistics of the .338 Lapua, and now the .300 Norma are undeniably wonderful, but does the expense of these two target rounds make them a viable choice? Can you serve your needs with a 6.5 Creedmoor or .300 Winchester Magnum, both of which are readily available at a fraction of the cost? That's up to you in the end.

In the hunting world, we have volumes available regarding the established

minimum calibers and energy figures, which have been memorialized for decades. However, the modern advancements in bullet technology — higher BC figures and tougher construction, namely — have changed the game. I can only imagine what Col. Townsend Whelen would say about a monometal hollowpoint or a bonded core, polymer tipped boat tail. If the gun writers of yesteryear could have a whirl with our premium bullets and slow-burning powders, I think they'd form different opinions than what they put into

print years ago. While Elmer Keith felt that the .30-06 Springfield was under-gunned for elk, and ridiculed Jack O’Connor for using the “puny .270,” I know hunters who cleanly take elk each year with a 6.5 Creedmoor and a 140-grain premium bullet. Does that make the .338 Winchester Magnum an obsolete elk gun? Not at all! If you shoot it well, it will still take an elk as cleanly as it did in the late 1950s. But it might mean that if you have a good ’06 or 7mm Remington Magnum, you have a damned-fine elk gun right in your hands. The same can be

said for bear cartridges. If you’re heading to Kodiak Island, I feel comfortable recommending the biggest cartridge you can handle effectively as the coastal brown bear is a force to be reckoned with, but for black bear and interior grizzly, your deer rifle, if mated with a heavy, premium bullet, might just get the job done well.

.30 Nosler, .300 Winchester and .30-06 Springfield will all launch a bullet at respectable velocities.

The 6.5-284 Norma loaded with 160-grain Hornady InterLocks makes a great medium range choice.

For long-range deer, sheep and caribou hunting, the high BC bullets we've been talking about throughout this book will definitely give that old .270 Winchester or .30-06 Springfield a facelift, and make hitting the vitals easier. Perhaps you're interested in one of the new short, squat magnum designs. There is a lot to be said for the shape of a particular powder column, but remember that a .308-inch diameter 165-grain bullet has no idea about the case from which it was launched, and as long as the cartridge has proven its accuracy at the target range,

velocity is … velocity. I’ve read arguments about the so-called huge difference between the field performance of the .300 H&H Magnum vs. the .300 Winchester Magnum vs. the .300 Weatherby Magnum. In all sincerity, we are talking about a difference of about 150 to 200 fps at best, and as long as you have done your part to make that distant shot (knowing your trajectory, reading the wind, etc.) I highly doubt that any game animal would be able to tell the difference. If they did, and the energy figures were that crucial, it might be

wiser to jump to a larger bore diameter with a bit more striking energy rather than split hairs. Again, I’m not going to advocate hunting large bears with a .243 Winchester, or go on record as saying you need a .35 Whelen to kill a deer, but if you stay within logical boundaries, you’ll be a happy hunter.

Looking at the light medium calibers such as 6.5mm and .270, you’ll see many choices that can give a hunter years of positive results. These days the 6.5s are all the rage, and with good reason: they yield excellent ballistics without a whole

lot of recoil. I’ve been telling you about my 6.5-284 Norma, which I’ve fallen in love with as a medium game cartridge. The 6.5 Creedmoor is also gaining quite the reputation in the field, and we’ve had the 6.5x55 Swedish Mauser for over a century, a cartridge sadly overlooked. The .260 Remington has no flies on it, and the fast 6.5s — the .264 Winchester Magnum, .26 Nosler and 6.5-300 Weatherby Magnum — drive some of the flattest trajectories available in their class. While the magnum-class 6.5mm cartridges are certainly designed for long-

range work, even the 6.5x55 Mauser makes a good hunting cartridge, fully capable of using a range of bullet styles and weights that will handle most of the average hunter’s needs. With a high BC bullet in the 140-grain range, like the Hornady ELD-X or Nosler AccuBond Long Range, you have quite the shooter in your hands. If you spend most of your time in the woods, where shots are within the 200-yard mark, there are some good 156- and 160-grain bullets, like the Hornady InterLock and Norma Oryx that will handle deer, bear and hogs without

an issue. Their high sectional density figures will ensure proper penetration, and their round-nose or semi-spitzer conformation is no handicap at the shorter ranges. The twist rate of most 6.5mm barrels is 1:8 or 1:9 at worst, so bullet stability is no problem, unless you get into the truly long-for-caliber projectiles. These features are why the 6.5mms are making their resurgence, sometimes in newer guises like the 6.5 Creedmoor or the .260 Remington, but I chuckle a bit when I compare them to the Swedish Mauser, and wonder why we

Americans didn’t see the writing on the wall decades ago, like the Scandinavians did. I often run my 6.5-284 Norma at Swede velocities for much of my local hunting, and it works just fine. Of course, by handloading the ammo, I can also choose to bring it up to full-house velocity, for even longer ranges.

The Creedmoor and Grendel cases deliver top-notch accuracy.

The .270 calibers, whether Winchester, Winchester Short Magnum or Weatherby Magnum, all make good all-around big

game choices, especially with today’s premium bullets. Load a 150-grain Swift A-Frame or Nosler Partition in your rifle, and you’ve got a bullet that will withstand the high impact velocities of a close-up shot, yet still open up at longer distances. If you prefer the better wind performance of the spitzer boat tails — and there’s no reason not to like them — there are all sorts of choices for these three cartridges. The Federal Trophy Bonded Tip, Swift Scirocco II, Barnes TTSX and others help retain the high velocities generated by the .270s as well

as maintain structural integrity to reach the vitals on bigger game. I know Professional Hunters in Africa who use a .270 Winchester with premium bullets for animals such as eland (which can approach one ton on the hoof) with great success. They pick their shots carefully, and keep the distances as close as possible, but it works like a charm. Those same bullets will handle elk and moose because of the controlled expansion. For deer and smaller cervids, the standard cup-and-core bullets will do a good job, but beware the close shots, especially

with the high BC spitzer boat tails, as they have a tendency to separate jacket and core when impact velocities get too high.

For target shooters, there are a few really good choices in the 6.5mm class, with the 6.5-284 Norma leading the pack. I chose this cartridge for a hunting round, based upon its performance at 1,000-yard targets, as well as its velocity capabilities. Many F-Class shooters choose to use this case combined with a 28- or 30-inch barrel to wring as much velocity from the case as possible. With this combination

you can drive a 140-grain bullet to 3,000 fps, and get highly consistent results. I’m sold on the 6.5-284 Norma because of its accuracy; my own rifle with a 25-inch barrel will maintain ⅓ MOA out to 500 yards or so, which is much more than I would ever expect from a hunting gun. The Creedmoor and Grendel also exhibit fantastic accuracy, and I’d comfortably recommend either for a target gun. All the 6.5 cartridges have the ability for excellent accuracy, even the 6.5 Carcano, whose inaccuracy claims lie more with the rifle than with the cartridge. The

bullet selections for the 6.5s are what make them shine, and I think they are going to stay at the top of the heap for years to come.

Moving upward to the 7mm and .30 caliber cartridges, there’s an amazing amount of choices, with a whole ton of overlap. In addition, the differences between 7mm and .30 are minimal, and often the decision comes down to personal choice. Yes, the .30 caliber cartridges can use heavier bullets than can the 7mms, but the advancements in bullet construction have narrowed the

performance gap, at least terminally. I like to break these cartridges into three categories: standard, magnum and super magnum.

Which will best serve your needs? Again, it’s a subjective answer, with many shooters being fervent defenders of their choice. I look at it this way: with the exception of some of the lever-action choices, like the venerable .30/30 WCF and 7-30 Waters (which are still great choices, in their element) you can choose just about any of the popular 7mm or .30 calibers and get the job done. Even the

older rimless designs, like the 7x57mm Mauser, .30-40 Krag and .300 Savage can still be used very effectively as hunting cartridges, benefitting from the modern bullet designs and advancements in powder technology. From a hunting perspective, almost all of these cartridges (minus the lever gun cartridges) can be zeroed at 200 yards with even the slowest posting acceptable, if not stellar trajectories when using modern bullets.

In the Sevens, you’ve got the 7x57 Mauser, 7mm-08 Remington, 7x64 Brenneke and .280 Remington in the

‘standard’ class, and all make a good choice, especially for the recoil sensitive. The oldest, the 7x57 Mauser, suffers from what I call “old rifle syndrome,” in that there are many 19th century rifles still in service, and many of the factory loads are adjusted for the older, weaker steel of those rifles. However, as a handloaded cartridge, the 7x57 is a hidden hero. The 7mm-08 is a bit limited in case capacity, often precluding some of the longest, highest BC bullets, but with proper bullet selection it can be a wonderful hunting round, and performs very similar to its

big brother, the .308 Winchester. The .280 Remington has become a bit of a sleeper these days, for reasons I just don’t understand. As the .30-06 necked down to hold 7mm bullets, it gives ample case capacity for the longest of 175-grain bullets, and has always been an accurate cartridge. It’s not really far behind the velocities of the 7mm Remington Magnum, yet has quite a bit less recoil. With 140-grain bullets, the .280 makes a great deer cartridge, for all conditions, yet with the 160- and 175-grain premium bullets it will neatly handle elk and

moose, as well as African plains game. The 7x64 Brenneke falls slightly behind the .280 Remington in the velocity department, but still offers enough to the hunter to make a good choice for an all-around rifle. If you want a ‘standard-class’ 7mm, any of these will make you happy. If you’re into the classics, owning a 7x57 Mauser is a good way to get back to roots, and with modern bullets you won’t feel handicapped at all. Actually, the 7x57 has taken all kinds of game, including African elephants, though there are better choices for the truly big game.

I'd personally opt for the .280 Remington, as it offers the most flexibility of the lot.

The 7x57 Mauser still delivers, well over a century later.

Heading into the ‘magnum-class’ you’ll find more than a few offerings. The 7mm Remington Magnum leads the pack — even having unseated the .264 Winchester Magnum in its early years — but there are others in the same power range. The 7mm WSM, 7mm Remington Short Action Ultra Magnum, .28 Nosler, 7mm Dakota and 7mm Weatherby Magnum are all similar in performance to the 7mm Remington Magnum, with varying levels of availability. The Remington version pushes a 150-grain bullet to about 3,100 fps and the 175-

grainers to right around 2,900 fps. This velocity gives ample performance in windy conditions, as well as a respectable trajectory. The premium bullets cause good penetration and expansion.

The .308 Winchester loaded with 165-grain Sierra GameKing hollowpoints.

The ‘super-magnums’ give a boost in the velocity department, pushing the 150s to 3,300 fps, and 175s to 3,100 fps or so. The 7mm STW and the 7mm Remington Ultra Magnum are huge cases, holding in excess of 95 grains of powder, and while the performance is unparalleled, the recoil is as well. Unless you’ve got a muzzle brake on these shoulder pounders the recoil can easily become too much for the average shooter.

Looking at the .30-caliber cartridges, you can lump them into the same three groups, but there are more choices. Let’s face it. Americans simply love .30 caliber. And the amount of cartridges available for it are staggering. In the ‘standard class’ I’m going to include the .300 Savage, .30 T/C, .308 Marlin Express, .308 Winchester, .30-40 Krag, and .30-06 Springfield. Yes, I’m aware of the raging argument between supporters of the .30-06 and those behind the .308 Winchester, but I’ve often felt it’s a moot point. There is maybe 100 to 125 fps

difference between the two and, again, I don’t think that game animals can tell the difference. Yes, the .30-06 uses heavier bullets a bit better and is a welcome addition to just about any hunting camp, anywhere. But the shorter cartridges were all (generally) designed to mimic the .30-06’s performance, with varying degrees of success. I’m not about to pick on anyone’s choice of cartridge, but this many redundant designs — with only minor dimensional variations — means some of them will be put out to pasture, and that’s unfortunate if you own one.

Like the WSSM series, where ammo is rare at best, some of these are headed for obscurity. At any rate, it is the performance of the .30-06 Springfield that has become the benchmark against which all other cartridges have been measured, for the last century.

Some .30 caliber cartridges. Left to right: .300 RUM, .300 Winchester Magnum, .300WSM, .30-06 Springfield and .308 Winchester.

Take things up to the ‘magnum-class’ and you’ll find some highly respected cartridges like the .300 H&H Magnum, .300 Winchester Magnum, .308 Norma Magnum and .300 Weatherby Magnum. Some of the recent developments in this class include the .300 WSM, .300 Remington Short Action Ultra Magnum, .300 Ruger Compact Magnum and .30 Nosler. Generally speaking, these cartridges give a 150 to 300 fps increase over the .30-06 Springfield, pushing a 180-grain bullet somewhere between 2,900 fps and 3,150 fps. Such cartridges

are among my favorites in this class, and as you can tell from the examples I’ve given in this book I’m rather partial to the .300 Winchester Magnum. To me, it represents a blend of acceptable recoil and good ballistics, being fully capable of using the full spectrum of .30 caliber bullets, without being too awful rough on a barrel. I also like the .300 H&H Magnum — though more for its nostalgic aura than anything else — even though it’s at the bottom of the velocity list for the magnums. It has a ‘sweet’ recoil, if you will, being much easier on the

shoulder than say a .300 Weatherby, yet makes a very effective hunting round. Professional Hunters in Africa smile when you uncase a .300 H&H (or Super .30 as it’s also known) as they know how that round will perform on plains game.

The .30 caliber “super-magnums,” like the .300 Remington Ultra Magnum and the huge-cased .30-378 Weatherby Magnum, are a whole different level of cartridge. Both will drive a 180-grain bullet to 3,350 fps, and can generate some soul-crushing recoil. If you’re looking to really move a bullet, these are

your guys, but you’re going to want a muzzle brake. I’ve only shot one rifle in this class, a Remington Model 700 AWR in .300 RUM, that didn’t ring my bell.

So among the choices in the two most popular calibers for an all-around rifle, how does one choose what is best? Try them, and try as many as you can. If you’ve paid attention to the science involved with a bullet’s flight path outlined and explained earlier in this book, you can easily see that the case — so long as it gives consistent, desired results — is not the biggest player in the

game. Among these cartridges, I like to look at two things: my anticipated ranges, and the required horsepower. If I’m hunting in a situation that may require a longer shot, say out past 300 yards, I appreciate the trajectory and wind deflection qualities of my .300 Winchester Magnum. However, if I’m hunting the woods and mountains around home, where I know my shots are rarely over 100 paces, I’m fine with the .308 Winchester, as it’s a nice, compact rifle that provides plenty of accuracy. The ballistics for a woods rifle are a different

consideration than for long range. The .308 Winchester represents a great blend of accuracy and mild velocity, so you’re not stressing the bullets out with super-high impact velocities. I have, and will use my .308 Winchester in the woods, I just try and match the projectile to the job, so I don’t end up with premature bullet breakup, or an excess of bloodshot meat.

If you don’t want to own a bunch of different caliber rifles, the .30-06 Springfield makes a great universal compromise, giving the best balance of

both worlds, as well as being readily available. The ’06 is popular because it’s readily available, and it’s readily available because it works so well. The same ideas will translate into the 7mm world (if you haven’t figured it out yet, I’m a bit more partial to .30 than 7mm). If you keep your shots relatively short, there’s no real reason to exceed the .280 Remington’s performance, but there’s nothing saying a 7mm Remington Magnum won’t work up close. If you choose a caliber for use in the ‘wide, open’ places, the 7mm Remington

Magnum may suit you better. The super-magnums are a different story.

The versatile .30-06 Springfield is a great choice if you want to own just one medium caliber rifle.

I load a lot of super-magnums for different clients, and I understand the mentality: they want the fastest, flattest shooting, hardest hitting cartridge money can buy. However, these cartridges will definitely test the mettle of a cup-and-core bullet, and can make a God-awful mess on close shots. I’m not going to say that I dislike them, but I’m more comfortable with the 7mm Remington or .300 Winchester than I am with a 7 STW or .30-378 Weatherby. With the lighter cartridge, I can still make hits out to my own self-imposed distance limits, and the

wear and tear on both shooter and gear is much less.

Some of these cartridges also make fantastic target cartridges, for obvious reasons: they utilize the benefits of the heavier, higher BC bullet. The .308 Winchester is a darling in the target community, as is the .300 Winchester Magnum. The .300 WSM also holds its own on long-range targets. The ability to launch high BC bullets at a decent velocity, more than conformation, is the key.

Getting above .30 caliber, you’ll find the 8mm cartridges, which have a limited following these days. Bullet weight usually ranges between 150 and 220 grains, at .323-inch diameter, and they don’t offer much more than any .30 caliber. While there’s no denying the impeccable reputation of the 8x57mm Mauser, truth is the 8mm Remington Magnum and .325 Winchester Short Magnum are fast becoming obscure, and ammunition a rarity. If you have a good 8mm rifle, there’s no reason to retire it, but unless it’s an 8x57, you’d better be a

diligent shopper or reload your own.

The cartridges between .338 diameter and .358 diameter are reserved for larger game, like grizzly, moose, elk, etc. There are some cartridges still thriving that are best suited for deer like the .35 Remington. But many of these are big game specialists. There are some cartridges in this group based on the .308 Winchester case such as the .338 Federal and .358 Winchester, and others based on the .30-06 Springfield like the .338-06 A-Square and .35 Whelen. Then there are cartridges based on the .375 H&H

Magnum case, shortened to varying degrees. The .350 Remington Magnum is the shortest, while the .358 Norma and .338 Winchester Magnum proudly wear the family belt, as does the .340 Weatherby Magnum. Between the two bore diameters, there seems to be a ballistic advantage with the .338 cartridges, as the maximum bullet weight between the two is (generally) 250 grains, thus the better SD and BC figures tip the scales in favor of the .338. Not unlike my thought pattern with the 7mms and .30s, the cartridge that suits you will depend on

your recoil tolerance, and anticipated distances. The cartridges in this class — even the diminutive cases of the .338 Federal and .358 Winchester — offer a considerable increase in frontal diameter over the .30 calibers, and the heavier bullet weight will generate more kinetic energy. But, that increase comes at a cost, and that's increased recoil. While I find the .338 Federal, .338-06 A-Square, .358 Winchester and .35 Whelen to be 'sweet-shooting' (and fully capable of taking just about any North American species), the .338 Winchester Magnum and .340

Weatherby can be tough, especially at the bench. If you're looking for a bigger bore to pair with your 7mm or .30 perhaps to take to Alaska, I'm a fan of the .338-06 A-Square and the .338 Winchester Magnum. These two cartridges are very versatile, using good bullets weighing between 180- and 250-grains. The .338-06 sort of mimics the venerable .318 Westley Richards, pushing the big 250-grain bullets to just about 2,400 fps, while the .338 Winchester Magnum betters that figure by another 250 fps. Recoil rises dramatically, though, and

gets even worse with the .340 Weatherby and its bigger sibling, the .338-378 Weatherby. I’d highly advise you to ‘try-before-you-buy’ with the latter two cartridges, and make sure you can handle the heat. I’ve tried them, and they’re not for the faint of heart.

ABM’s .300 Winchester makes a great long-range target load.

The various .35s are not a bad choice, but give up some critical BC and SD values to the slimmer .338s of the same weights. If they suit your needs, go for it, but I think you’ll find the ranges of the

.35 calibers are a bit limited in comparison.

For the target crowd, this group contains one of the nastiest available: the .338 Lapua. Based on the .416 Rigby case necked down to use .338 bullets, the .338 Lapua will definitely reach out and touch someone, in a very dramatic fashion. There are some fantastic 300-grain match bullets available, as well as lighter ones that will retain velocity very well. Look for a good muzzle brake on a rifle chambered for this cartridge, as the recoil is brutal without it.

THE BIG BORES

Stepping up the ladder to the big bores — those cartridges designed for taking the largest game on earth — there are all sorts of choices, from the 9.3mm and .375 bores, to the lower .40s and .45s, up to the big .470s, .500s and above. While most of these are associated with African dangerous game hunting, there are some American offerings that have become classics.


ABM
338 Lapua Magnum
20 Centerfire
Rifle Cartridges
ABM

The beastly .338 Lapua is a true long-range cartridge. It’s based on the .416 Rigby necked down to .338.

If you’re serious about dangerous game, you’ll need a rifle of at least .375-inch diameter, though there are a few spots where the 9.3mms are acceptable. Tanzania requires a .375 or bigger for all dangerous game, including lion and leopard, while other countries only require them for elephant, buffalo, hippo and lion. The .375 is just the minimum, and there are some good choices above the .375, but I’m willing to go on the

record saying this: for a global hunter, the .375 H&H Belted Magnum is the most useful cartridge ever invented. Yup, I said it. You can literally hunt anything on the planet with a good .375 H&H, and I suppose the same can be said for the .375 Ruger. With bullets ranging from 235 to 350 grains, and a trajectory that mimics a .30-06 Springfield, the .375 H&H has been used on 20-lb. steenbok, 100-lb. impala, 600-lb. kudu, 1,500-lb. Cape buffalo and 12,000-lb. elephant, for over a century. Among the big bores, it is relatively easy on the shoulder, very

accurate, and has a selection of bullet profiles that will allow it to shine on 20-yard shots, as well as 400-yard shots. I’ve used it in both North America and Africa, and it makes just about one of the best bear guns ever, for both black and brown. Getting this right out of the way, if you’re looking for a bigger rifle to pair with your medium, it makes all the sense in the world to make it a .375 H&H. Comparing the ballistics, it will push a 250-grain (obviously of less sectional density) to a faster muzzle velocity than the .338 Winchester Magnum, and with

the heavy 350-grain Woodleigh round nose bullets at 2,150 fps, will cleanly dispatch an elephant. I’ve had several .375s, including a Winchester Model 70 that I love, and an excellent Legendary Arms Works Big Five, which my wife snapped up as her own (when I’m good, I still get to shoot it), and both print sub-MOA groups with many different types of bullets. The fact that it is the legal minimum for Africa makes it such a viable choice there, but as an elk or moose gun, it’ll push a 260-grain Nosler AccuBond to almost 2,750, so it really

isn’t a short-range thumper like a .458 Winchester or .458 Lott.

The .375 Holland & Holland Rimless Belted Magnum — in the author’s opinion the most useful cartridge ever devised.

Legendary Arms Works Big Five rifle, chambered in .375 H&H Magnum.

That aside, for the true heavyweights like Cape buffalo and elephant, there are larger choices that just might get the job done even better. Having hunted both, I

can say that more bullet weight translates to a quicker kill. Regarding buffalo, a .375 H&H will definitely kill them, but a cartridge in the lower .40s — like the .416 Rigby, .450/400 3-Inch NE, .416 Remington, .416 Ruger and .404 Jeffery — will have a noticeably different effect, stunning the bulls, if you will. The .416s push a 400-grain bullet to 2,400 fps, the Jeffery about 100 fps lower and the .450/400 will drive them to just under 2,100. These cartridges handle elephant quite nicely, as the lower recoil (compared to the .45s and .500s) allow

you to place the shots accurately, and the high SD figures promote all kinds of penetration (remember those Woodleigh Hydro solids?). Among the big bores, this class of cartridge is my personal favorite, as they blend the hard-hitting attributes of the bigger calibers with the long-distance capabilities of the .375 H&H. Among these, I like the .404 Jeffery — my Heym Express is my favorite rifle — the .416 Remington Magnum in a bolt rifle, and the .450/400 3-Inch NE in a double rifle.

While I like the lower .40s for my own use, there’s no denying that the larger

calibers, the .458s and .500s, will stop a charging animal better thanks to a heavier bullet and larger frontal diameter. These are the truly big sticks, and require serious practice to master. The recoil of the .458 Lott and others like it (especially off the shooting bench) can be really nasty. I recommend that once rifles in this class are sighted in, get off the bench and do your practicing off of shooting sticks or off hand. There are quite a few to choose from, including the .458 Winchester Magnum, .458 Lott, .450 Rigby, .450 3 ¼-Inch NE, .470 NE, .505

Gibbs, .500 Jeffery and .500 NE, depending on whether or not you prefer a double rifle or bolt-action gun. The .45s launch a 480- to 500-grain bullet at velocities between 2,100 fps and 2,400 fps, for over 5,000 ft.-lbs. of kinetic energy. The .500s use a 525- to 535-grain bullet, at similar velocities.

The .458 Lott will stop any creature God put on this planet.

Heym Express in .404 Jeffery makes an excellent choice as an all-around cartridge for truly big game.

The venerable .45-70 Government is still going strong.

While I’m aware the market for this kind of rifle is limited, as they don’t have a great trajectory, they nonetheless work very well up close. They’re specialty

rifles for sure, but they serve their purpose.

Those American big bores I was talking about? The .45-70 Government, .38-55 Winchester, and .444 Marlin are all popular with the lever-gun community, and while they’re short-range affairs, they have devoted followers. If you like things on the larger side of average, they can be a bunch of fun to shoot and hunt with, and will work for even the largest game, if the range is right.

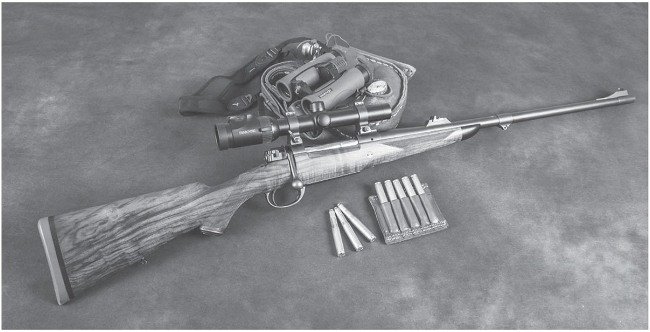
MAKING THE CHOICE

So, if you know your hunting or shooting expectations, I hope this guide will help point you in the right direction in choosing a rifle cartridge. Here’s what I use, and I don’t offer it up so you mimic my choices, but to explain why I chose them.

The author’s Ruger 77 in .308 Winchester serves him well to this day.

Like many shooters, my first rifle was a .22 LR, a Ruger 77/22 that I still shoot three decades later. My first big game rifle was a .30-30 Winchester 94, a gift

from my Dad. After that I moved up to a Ruger 77 Mk II in .308 Winchester, a great deer rifle that has taken many good bucks and a black bear as well. I took it on a moose hunt where I decided I needed a much bigger cartridge (not exactly correct, but I digress). I ended up with a Winchester Model 70 in .375 H&H Magnum, as my goal was to head to Alaska for moose and grizzly bear. I ended up in Africa instead.



The author’s prized Heym Express in .404 Jeffery.

I added a .300 Winchester Magnum into the mix, for a long-range gun, and used it and my .375 on my first safari, with great success. Shortly after, I got into calling coyotes, and invested in a Ruger 77 in .22-250 Remington, as I

wanted a dedicated predator rifle. It has accounted for many coyotes and foxes, as well as varmints. At an SCI dinner, I won a raffle for a Winchester 70 in the caliber of my choice, and as I had booked a Cape buffalo hunt, ordered it in .416 Remington Magnum, and loved it. I used this lineup for quite a while, until I became a gun writer and had a chance to experiment with many different calibers. I fell immediately in love with the 6.5-284 Norma, and ordered one from the Savage Custom Shop. But, it was the loaner rifle I received from Heym, for a

combination plains game/elephant safari, which spun my head around. It was the Martini Express rifle, in .404 Jeffery, and it was the sweetest bolt gun I’ve ever used. I took a pretty impala ram, and a nice wildebeest bull, but the non-export elephant I took at 16 paces was far and away one of the best hunting moments of my career. That gun fits as if it were built for me (Heym rifles are made to order), and the .404 Jeffery is as cool and nostalgic as a cartridge gets. I loved it so much that I sent a check instead of returning the rifle. I’m also in the process

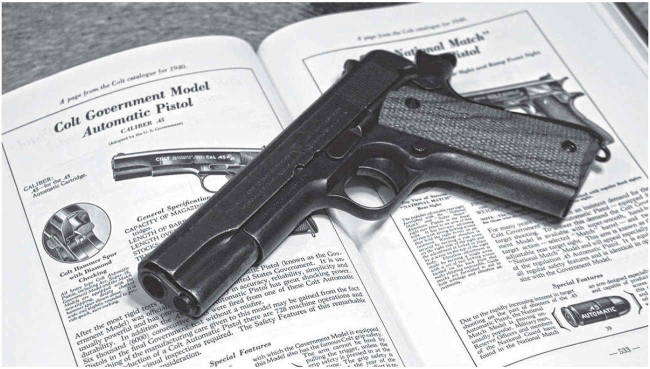
of building a .318 Westley Richards, as I adore the classic African cartridges.

So there you have it. A good .22LR, a predator rifle, a 6.5-284 for lighter game, a trio of .30s for short- and long-range work, a .318 just because, a .375 H&H for anything at all, and a .416 Remington and .404 Jeffery for the heavyweights. There are other guns, but they don’t mean as much to me as do these.

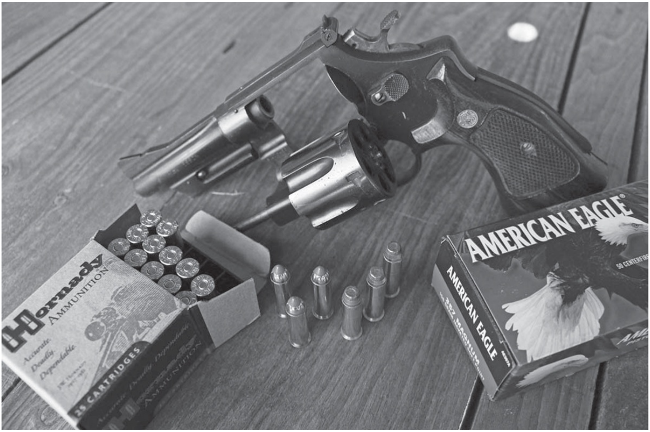
HANDGUN CARTRIDGES

No less fervent than the rifle cartridge debate, handgun cartridge choices are backed by hordes of fervent supporters;

each makes their case and believes firmly in their cause. Whether it's a defensive handgun or a hunting rig, there's something for everyone. Let's tackle the defensive handguns first.



The classic Colt Model 1911 in .45ACP — a favorite fighter for many generations.



The .357 Magnum packs a wallop, but can make even seasoned shooters flinch.

Deciding on a cartridge to defend yourself is no easy task. You want the ability to neutralize a threat and get to safety, but there are many different

schools of thought. I’ve always subscribed to the “bigger is better” mentality, but the aspect of size and the ability to conceal the pistol becomes an issue, too. Reading the works and advice of trailblazers like Col. Jeff Cooper, you’ll find a definite recommendation for the .45 ACP, and with good cause. I know of few other pistol cartridges — save perhaps the 10mm Auto — that will equal the .45 ACP’s performance. However, there are a multitude of choices that, while perhaps not as powerful as the .45, are easily carried and will reliably

save your bacon. The 9mm Luger is an obvious choice, as are the .38 Special and .357 Magnum. There is nothing wrong with the .40 Smith & Wesson, or the .327 Federal. You’ll have to find a cartridge that is available in a handgun that suits your style, has enough power to get you out of trouble, and that you can shoot effectively. The largest magnum in the world does you no good if you can’t hit what you’re aiming at.

While volumes have been written about the penetration tests of different calibers, and there are Internet forums

that would have you thinking that anything less than the cartridge du jour would simply bounce off of an attacker, I personally wouldn’t want to be shot by any handgun, including a .22 LR. It would be wise to see if you could try some of the varying handgun cartridges before you make a purchase to verify that you are comfortable with your decision. I know many grown men who, when handed a lightweight alloy revolver chambered in .357 Magnum, wince at the recoil from the first shot. Some guns just aren’t comfortable. I personally prefer

revolvers, as I grew up shooting Dad’s Ruger Single Six, and the feel of a wheelgun comes naturally to me, but I also appreciate the autoloaders. My own carry gun is a .38 Special Smith & Wesson Model 36, a five-shot revolver with a 1-⅞-inch barrel. I chose it for its reliability and small size; it has a nice set of Pachmayer grips that fit my hand perfectly, and for my purposes the short barrel poses no handicap at all. While the .38 Special is no powerhouse cartridge, it will send a 158-grain bullet at over 800 fps, for a combination that is perfect for

me. It’s not the .357 Magnum, and it’s not the .45ACP, but it has served law enforcement well for decades, and I know it will do the same for me. The recoil is more than manageable, but the report with the lighter 110-grain bullets at +P velocities can ring your bell, and I have tinnitus already so I prefer the ‘heavy and slow’ school of thought. I can accurately place my shots out to 15 or 20 yards, and don’t expect to have to use this handgun any farther than that. Again, this is just my choice; I can use the good defensive ammunition, or I can handload

wadcutters or cast lead bullets for practice and plinking.

The Smith & Wesson Model 36 in .38 Special is compact, concealable and powerful enough to get you out of trouble.

I sat down with a couple good friends who teach defensive handgun classes, and got their take on the age-old self-defense caliber debate. Mark Nazi and his dad Lek own Double Eagle Tactical Training (www.DoubleEagleTactical.com), a school for all levels of handgun instruction. Both father and son have extensive experience with a variety of handguns, from classic wheelguns to the latest polymer-frame autoloaders, in addition to providing safety and accuracy training to quite a few people each

month. I’ve spent time in their classroom, as well as on the range, and there’s no doubt in my mind that these two know what they’re talking about when it comes to defensive handguns and cartridges.

We sat at the table, when all the guns were cleaned and put away, and that’s when the debate began to kindle, slowly at first, like the first lick of flame on a piece of paper. It then began to rage, as the fuel took the flame, and before I knew it, father and son were in a vein-popping exchange that rivaled firearms debates I’ve had with my own father. You see,

Lek, having many more years of experience than Mark, leans heavily on the tried and true .45 ACP and its heavy bullet weight as a defensive weapon. Mark, meanwhile, is a law enforcement officer trained with the lighter calibers, and is more of a 9mm guy. I totally get the dichotomy, and sat back while the two bickered, taking in the points of each argument. This debate is nothing new; it is as old as the .30-06 Springfield vs. .308 Winchester argument. One side insists that the .45 ACP is the only viable option, and that any lesser cartridge is simply a

waste of time. The other looks at energy figures, modern propellants and bullet technology, and the size and weight of the handguns for these smaller choices.

“The .45 ACP is the way to go when it comes to concealed carry,” asserted Lek. “Simply put, the bigger the round, the bigger the hole. If there is a guy coming at you and you have to choose between 19 golf balls or 8 bricks to stop him … I’m going to choose the brick every time.”

“You had better make those 8 bricks count!” replied Mark.

“You know I can, boy.”

And with those opening volleys the debate commenced.

“When it comes to concealed carry, I’m going to go 9mm Luger every time,” Mark retorted. “With all of the advancements in modern ammunition, the 9mm is right on the heels of the .45 ACP in a lot of factors. If I’m going to get into a gunfight, I’m going to take the reduced recoil for follow up shots and the extra magazine capacity that allows me to hold off on that first mag exchange. Not to mention the cheaper cost; the 9mm is the

‘Honda Civic’ of rounds — everyone makes some version of it.”

Lek and Mark Nazi, owners of Double Eagle Tactical Training.

The venerable .45ACP is, arguably, the king of defensive handgun cartridges.

But the elder Lek would have none of that.

“When it comes to the .45 think of it as a big, slow-moving brick,” Lek said. “It may not penetrate as far as a 9mm+p will but the massive amount of trauma will take the threat out of the fight quick and in a hurry. The more vital organs you can damage the quicker the fight is going to be over, the faster they bleed, the quicker they die.”

The modern 9mm loads are highly effective. Just ask any fan of the 9mm, they'll tell you.

Mark Nazi about to send another well-placed round downrange.

The .500 Linebaugh will get your attention!

“Size does not always matter, it’s more technique!” Mark said. “And that’s all fine and dandy — and I have to agree

with you that the .45 is a devastating round — but the wound cavity created from a modern 9mm bullet at +p velocity will take a person out of the fight just the same. The 9mm will penetrate more than the .45 due to its small diameter and you can apply that to ballistic vests, sheet metal, and bodies. The 9mm makes up for what it lacks in size with velocity."

The debate isn't over, nor will it ever be, as both make good points. I generally lean more toward the heavy .45 camp, but I understand the 9mm point of view, too. Modern bullets do, in fact, make a huge

difference is terminal performance. Like I said, I carry a .38 Special, which is not all that far from the ballistics of a 9mm, if it does have a bit more bullet weight, and I carry it confidently.

While I sat with my friends and let them duke it out intellectually about a topic that is older than the hills, I realized the choice of a defensive caliber really comes down to confidence. I’m not about to say that a high-energy cartridge like the .45ACP or 10mm Auto is too much gun, because in certain situations there is no such thing as too much gun. However,

carrying a handgun that you have confidence in, one that you shoot well, is a huge factor in the self-defense equation. Remember, you’re not invading Normandy; you want a cartridge that is going to get you out of trouble and into a safe situation. That will require training, good ammunition and tons of practice. If it’s with a .357 Magnum, so be it. If it’s a .40 Smith & Wesson, it’s all good. I think we can all agree that the bigger, the better, but it doesn’t necessarily need to be the biggest.

The 10mm Auto is a perfectly viable hunting cartridge.

Hunting handgun cartridge choices are a different story, as you'll need enough killing power to quickly dispatch the game you're after. There are traditional choices, like the .357 Magnum, .41 Magnum and .44 Magnum, as well as the .45 Colt and.454 Casull, but things keep getting bigger. Then there are the giants — .500 Linebaugh, .460 Smith & Wesson, and the .500 Smith & Wesson.

Even the 10mm Auto has made a recent splash in the hunting fields. Just before submitting this manuscript, my colleague Razor Dobbs took two Cape

buffalo in South Africa with a Dan Wesson 10mm Auto! That’s quite a feat, but goes to show how powerful these handguns can be. The 10mm is one of the few autoloader cartridges that make a good hunting cartridge.

Invariably, the predominant form of a hunting handgun is the revolver. It gives you a very strong action, and the positive headspacing of a rimmed cartridge. Smaller game can easily be dispatched with a good .22 Long Rifle revolver, and it’s a challenge to fill the pot with rabbits and squirrels taken with one.

Big game is a different story. I find the .357 Magnum to be a sensible minimum for a deer hunting cartridge, while the .41 and .44 Magnums, as well as the .45 Colt make excellent bear cartridges. Those bigger guns will take just about any game at sensible ranges.

Hunting small game with a .22LR handgun can be a fun challenge.

CHAPTER 19
READING THE WIND

I’ve shown you charts, discussed the choices of cartridge and bullet that will best perform in windy conditions, but no matter what you’re shooting, you need to know how to read the wind. It’s certainly not an easy prospect, especially as the distances get long. Yes, a Kestrel weather meter or similar will accurately indicate both the wind speed and direction in

relation to the target. This is definitely good information, but it is only a part of the puzzle. There will invariably be shooting situations where the wind at the target is completely different from the wind at your location. Couple that with variations in terrain, elevation and weather conditions, and you’ve got quite a chore on your hands.

‘Dog’ Pritchard helps out Dave Fulson with the dope on a 1,400-yard shot.

Reading wind is no easy task. As mentioned in previous chapters, I recently had the honor of spending quite

a bit of time beside Doug “Dog” Pritchard, an ex-Navy Seal who is not only one helluva shot, but an expert at calling wind. I got to play the role of both shooter and spotter with him, as I wanted to concentrate on learning to call wind for other shooters as much as shoot the long distances available at the FTW Ranch. It didn’t take long for me to figure out what Pritchard was basing his calls on, and why.

We’d look through the spotting scopes, observing several key indicators and comparing them to the wind directions

and values we were feeling at our location. Pritchard explained how he unravels the mystery, using little clues presented by nature, as well as knowledge of terrain and how winds behave in canyons and valleys. I can’t imagine a more difficult set of scenarios than those that are presented at the FTW Ranch. Tim Fallon & Company have handpicked some incredible shooting challenges that present steep angles, long distances, and impossible wind conditions. Some of these targets combine all three factors — to an

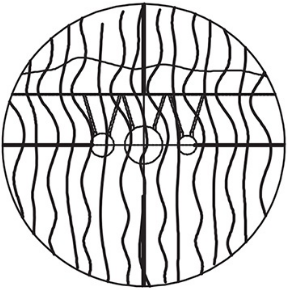
extreme degree — and really test the skill set of any experienced shooter.

The Barksdale area of Texas is canyon country, and the daily temperature differentials cause the winds to swirl, gust, calm down, and pick back up in a matter of minutes. We had to use every available piece of evidence to determine the correct call. We’d look for blowing grass, fluttering leaves; hell, we’d even use the butterflies to find out what was going on. Mirage, if it was present, was a definite help, as was the flight pattern of

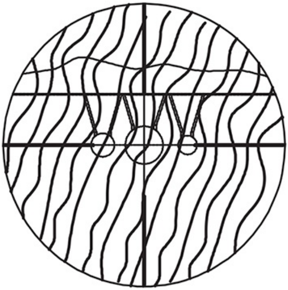
buzzards and other birds riding the winds and thermals.

USING MIRAGE TO ESTIMATE WIND VALUES

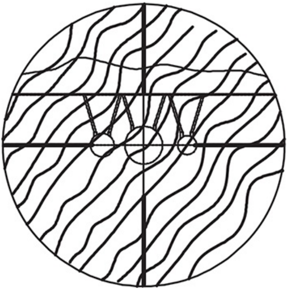
NO WIND
Straight up, or "Boil"



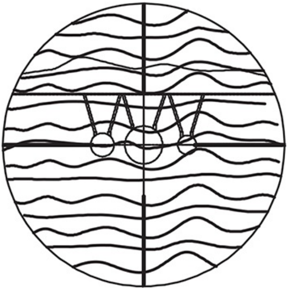
1–3 MPH
Slight bend, left to right



4–6 MPH
45° Run, left to right



8–10 MPH
Running Flat, left to right



Watching grass is a great indicator of wind direction.

Mirage is a phenomenon is which light rays are bent due to the heat difference of the ground and the air; if you’ve ever seen the heat shimmer on a hot asphalt

road you’ve seen mirage. You can use those bent light rays and the direction in which they are moving (if they’re moving at all) to help you with your wind observations. Looking through your spotting scope, if you see the lines of mirage ‘boiling’ or running vertically, you can assume a zero to 3 mph wind value. Should you find that mirage running at 45 degrees or thereabouts, you can assume a 3 to 5 mph wind value. If the mirage looks as if it’s running horizontally, but slightly broken up, your wind value will be 5 to 8 mph, and if you

see it running horizontally in a straight, consistent manner, you’ve got eight mph and up, and will be able to determine the factor with other methods. Mirage is most visible on a bright, sunny day. At FTW, when we would have trouble picking up mirage, we would use the spotting scope to focus on a point closer to the target, and like magic the mirage would appear. Even so, mirage is a useful tool only evident under certain conditions, so you need other clues to help make the correct wind call.

Grass is always helpful, as it is easily moved by the slightest winds. A 3 mph wind will move the grass, and a 5 mph will move grass significantly. Leaves are another aid that can really save the day. If you’re hunting in an area like Texas, where much of the vegetation holds onto its leaves year-round, you have many good indicators, but what if you’re hunting the Tioga, or the wide-open crop fields of the northern U.S.? Odds are, there will always be something to gauge the wind velocity, even if it’s the remnants of last autumn’s leaves or the

top of one of the stunted evergreens that grow at higher latitudes. If you’re a traveling hunter, and you’ve found yourself in a new environment where the foliage and vegetation seem foreign to you, a handheld weather station will come in very handy. If you watch the wind’s effects on the new flora, and measure that value with your wind meter, it will give you a much better idea of what the values will be while you are hunting. Cedar trees are a great indicator, as the tops act like a wind flag, and if you know what the wind speed is for certain

movements you’ll more than likely be right.

The valleys on the FTW Ranch make wind calls a challenge, to say the least.

If you’ve got some trees with full leaves, you can quickly ascertain wind

direction — even in light winds — by determining if there is movement on one side of the tree or the other. Pritchard and I were discussing, well, debating — OK we were nearly arguing — about a particular shot and what the wind values should be. I had (I thought) followed all the proper procedures, and made a call of ‘no wind,’ and had instructed the shooter to hold the left edge of the six-inch plate, to give the proper adjustment for spin drift at that distance.

“Nope, have him go right at it. You’ve got some right-to-left down there; it’ll

compensate for the spin drift."

I looked again, and again, and it wasn't there. I saw a butterfly float by, just as happy as could be, about half way to the target, and I couldn't pick up any mirage, so I didn't know what he was getting at.

"Where are you seeing wind, Dog? I got nuthin'."

"See that live oak, about 15 yards left of and above the plate? Watch those leaves just on the right edge; they're blowing ever so slightly at the top. Because of the bullet arc (the target was

700 yards out), that slight right-to-left wind will cancel the spin drift.”

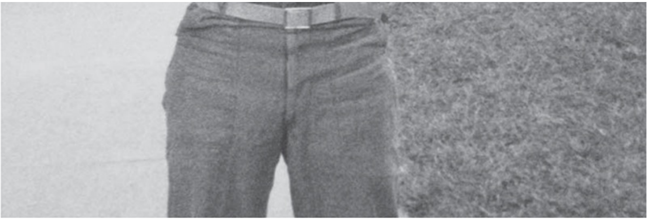
Dammit, I didn’t see it, and in my effort to shine in front of the Professor, I truly didn’t think to look at the top of the tree, in order to compensate for the entire trajectory arc of the bullet. The shooter held for the center of the plate, and I watched the paint splatter one-inch to the left of center. Professor Dog had given a clinic, and I learned my lesson. My wind call would’ve pushed that bullet off the left side of the plate.

Calling wind into or across a valley can pose an entire different set of problems. If you’re hunting or shooting in canyon country, the wind can behave much like water. You may see the tell-tale signs of the wind on the top of the hills, and though it may appear dead calm at the bottom of the valley, there may be wind acting much like a waterfall — rushing over one edge and creating an eddy of moving air along the wall of the canyon. I learned this difficult lesson at the ranch when we were set up on a range that predominately worked perpendicular

to the bottom of the valley, but had two targets that ran pretty much parallel to the valley wall. The most difficult shot was an 18-inch plate at 585 yards, along that wall. Where that plate was placed, the wall of the canyon got steeper than where we were shooting. The winds were just everywhere, if that makes any sense. Looking from our shooting position, it was clear the winds were hard, right to left, coming into the canyon, but I saw the slight left to right just in front of the target. It was a compound wind, in that it was definitely two different scenarios on

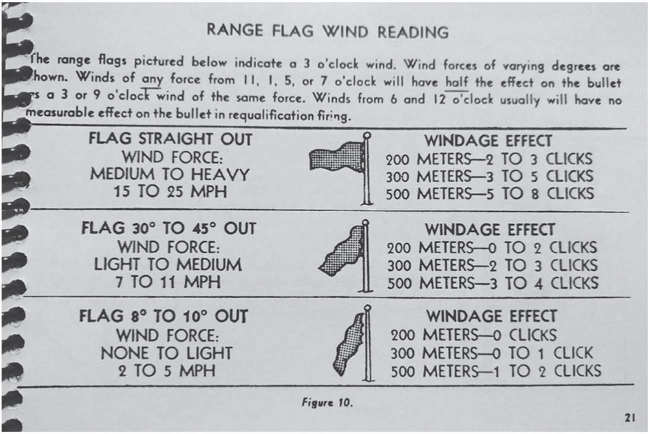
the way to the target. I was shooting for this particular exercise, but Pritchard insisted that I call my own wind. I looked and studied the scene, studied and looked some more, and decided that the predominant right to left wind would take precedence, and adjusted my hold into that right wind, and touched one off. In proud fashion Pritchard announced a miss, two feet off the right edge of the plate. The wind, hauling ass over that canyon wall, was curling much like water at the bottom of the valley, and rolling left to right. Once it was explained to me,

I shot the plate with no issue, but had that been a game animal, I'd have either completely missed it or — worse yet — wounded it.



Donald B. Thorne, Jr. at Parris Island.

Marine Corps shooting medals.



RANGE FLAG WIND READING

The range flags pictured below indicate a 3 o'clock wind. Wind forces of varying degrees are shown. Winds of any force from 11, 1, 5, or 7 o'clock will have half the effect on the bullet as a 3 or 9 o'clock wind of the same force. Winds from 6 and 12 o'clock usually will have no measurable effect on the bullet in requalification firing.

FLAG STRAIGHT OUT WIND FORCE: MEDIUM TO HEAVY 15 TO 25 MPH	WINDAGE EFFECT 200 METERS—2 TO 3 CLICKS 300 METERS—3 TO 5 CLICKS 500 METERS—5 TO 8 CLICKS
FLAG 30° TO 45° OUT WIND FORCE: LIGHT TO MEDIUM 7 TO 11 MPH	WINDAGE EFFECT 200 METERS—0 TO 2 CLICKS 300 METERS—2 TO 3 CLICKS 500 METERS—3 TO 4 CLICKS
FLAG 8° TO 10° OUT WIND FORCE: NONE TO LIGHT 2 TO 5 MPH	WINDAGE EFFECT 200 METERS—0 CLICKS 300 METERS—0 TO 1 CLICK 500 METERS—1 TO 2 CLICKS

Figure 10.

21

Marine Corps wind flags indicate wind direction and intensity.

These ideas, and other visual clues in the hunting fields, are what the SAAM course at the FTW is all about. Other shooting situations there, especially on

the longer shooting ranges, employed a multitude of flags to indicate both wind direction and intensity. It’s quite easy to understand what a great aid this is to any shooter, especially when you’ve got a good dope card or Kestrel unit at your side.

My good buddy Donnie Thorne served our country in the U.S. Marine Corps, as a machine gunner in Viet Nam. During basic training, he shot ‘Expert’ and attained the highest score in his platoon. I asked him to recall what he could about his training — it’s funny how Marines

never seem to forget that training — and he answered my inquiries as if he'd returned from basic two weeks ago.

"We were trained with the M14 rifle in 7.62 NATO, but spent days, literally days, with an empty rifle, practicing the proper sighting technique on a 55-gallon drum, with small black dots painted on it," Thorne recalled. "Sight alignment, in various positions from kneeling to sitting to standing to prone, was demonstrated and taught for hours on end. We'd mark targets for other recruits, and then return to sight practice. I only got to fire live

ammunition the day before qualification. We were allotted 50 rounds, to the best of my recollection, for practice. On qualification day, we shot targets at 200, 300 and 500 yards. I shot 228 out of a possible 250, earning the title of Expert, even landing 50 out of 50 at the 500-yard target.

“For wind compensation,” he continued, “we were taught to dial a certain amount on the windage adjustment of the rear peep sight, and the range flags would indicate both direction of wind and its speed, based on the

distance out from the flag pole. Obviously, the stronger the wind, the farther from the pole it will blow the flag, and we would adjust our wind hold based on the flag values. Our instruction booklet would give us the values, and the correlating rifle sight adjustments.

“It’s funny, learning trigger control and reading the wind in the Corps definitely helped me as a hunter; it also had a direct influence on my passion for single-shot rifles. I love a good target-style .22 Long Rifle, with a peep sight and a long sighting radius, as well as big game rifles

like the Ruger No. 1. Having just one shot, and the patience and precision to make it count, are things I attribute to the Marine Corps. I love the improvements in modern riflescopes and bullets, but at 66, I'm not much of gadget guy. I prefer relying on my training and practice, and if it's too far, I like to get closer."

Personally, I used to avoid shooting my rifles on really windy days, as the group size would start to fall apart. These days, I actually prefer to shoot in the wind, once the rifle and the load are proven, to better hone my wind-calling skills. I like

to observe how the trees and grass are moving, measure those values with my Kestrel, and make mental notes to keep myself sharp. If you practice enough it becomes second nature, and while there are difficult situations like I’ve described earlier, the more wind calling you do, the smaller the amount of error will become.

But, just as it is with all shooting, calling the wind requires constant mental exercise; you can’t do it once or twice a year and remain proficient. Wind is a predictable effect, assuming the values are known and things are constant.

Making correct adjustments to overcome those effects — that’s the key to successful shooting.

ACKNOWLEDGEM

Along the way, certain people come into your life and make a definite impact. I have been lucky to meet many of my heroes, as well as major players in the firearms industry, and now call them friends. In addition, a book of this magnitude takes up a huge amount of time — time that would normally be spent with family. I'd like to thank my darling wife Suzie, and my daughter Angelina, for being so understanding during the writing process.

I’d like to thank Marty Groppi for all of his help during this project; Marty is always there to help test new products or load some ammo for evaluation. Thanks bud, you’ve been invaluable. Robin Sharpless, at Redding Reloading, is possibly the best-educated man I know when it comes to ballistics, and if you’ve ever met Robin, you know what a kind soul he is. J.J. Reich and Jake Edson at Vista have been more than kind, providing insight and information; gentlemen, I can’t thank you enough. Chris Hodgdon, of Hodgdon Powders is

another fellow I’m proud to call a friend. Chris, I truly appreciate all that you do. Then there are the ammunition and bullet companies that strive to keep us all shooting. Neal Emery at Hornady, Zach Waterman at Nosler, Ron Petty at Norma, Dan and Samantha Smitchko at Cutting Edge Bullets, Kristof Aucamp at Peregrine, Carroll Pilant at Sierra, and too many others to name; you guys and gals work very hard, and I am most grateful. Katie Godfrey at Kestrel, Ryan Muckenhirn at Vortex, Chris Sells at Heym USA, and too many others to

name, thank you for your kindness and generosity. If I’ve neglected to mention your name, please accept my apologies; gun writers have only so much room on the mental hard drive.

Lastly, I’d like to thank Dave Fulson of Safari Classics Productions, firstly for being the clown that he is, and secondly for his unceasing efforts in promoting and preserving the positive images of hunters and shooters worldwide. Father Fulson, you’re one of the good guys.

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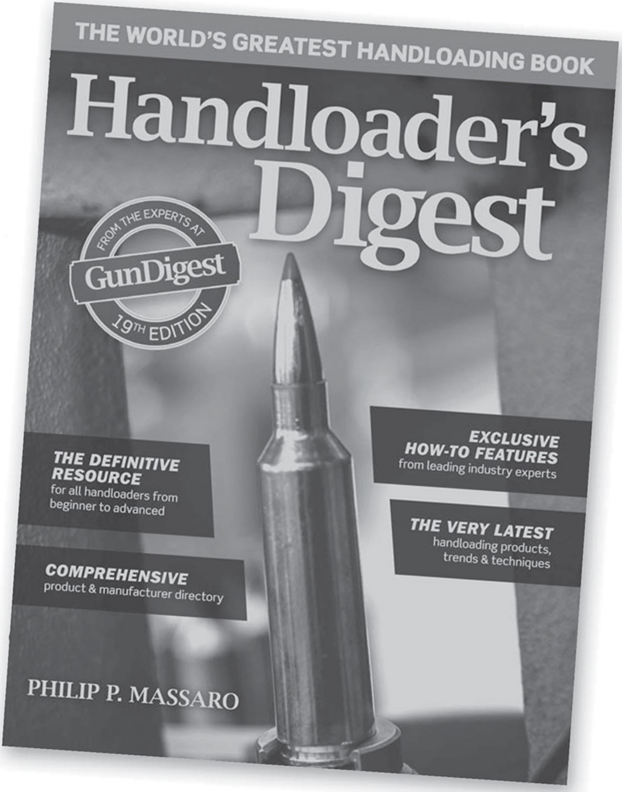
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Tables

RANGE(YARDS)	VELOCITY(FPS)	ENER L
Muzzle	2,960	3
50	2,868	3
100	2,779	3
150	2,691	2
200	2,605	2
250	2,521	2
300	2,438	2
350	2,357	2
400	2,277	2
450	2,198	1
500	2,122	1

550	2,046	1
600	1,973	1
650	1,901	1
700	1,831	1
750	1,762	1
800	1,696	1
850	1,631	1
900	1,569	9
950	1,509	9
1000	1,451	8

Return to main text

Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
0	-1.5	0.0	2,200	1,827
25	0.1	0.1	2,121	1,698
50	1.2	0.4	2,044	1,577
75	1.8	1.0	1,968	1,462
100	1.8	1.8	1,894	1,354
125	1.3	2.9	1,822	1,253
150	0.0	4.3	1,753	1,159
175	-2.0	6.1	1,685	1,072
200	-4.7	8.1	1,619	990
225	-8.2	10.4	1,556	913
250	-12.6	13.0	1,494	843
275	-18.0	16.0	1,435	777
300	-24.5	19.4	1,380	719

Return to main text

Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
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300	-31.6	19.4	1,380	719

Return to main text

Range (yd.)	Drop (in.)	Wind Drif (in.)	Velocity (fps)	Energy (ft.-lb.)
0	-1.8	0.0	2,880	3,039
25	-0.5	0.0	2,828	2,929
50	0.5	0.2	2,776	2,823
75	1.2	0.4	2,725	2,721
100	1.6	0.7	2,675	2,621
125	1.6	1.1	2,625	2,524
150	1.4	1.6	2,575	2,430
175	0.9	2.2	2,527	2,339
200	0.0	2.9	2,478	2,250
225	-1.2	3.6	2,431	2,164
250	-2.8	4.5	2,383	2,081
275	-4.8	5.5	2,337	2,000

300	-7.2	6.7	2,290	1,922
325	-10.0	8.0	2,245	1,846
350	-13.3	9.3	2,200	1,773
375	-17.0	10.8	2,155	1,701
400	-21.1	12.5	2,111	1,633
425	-25.8	14.2	2,067	1,566
450	-30.9	16.0	2,024	1,501
475	-36.6	18.1	1,982	1,439
500	-42.6	20.1	1,939	1,377

Return to main text

Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
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175	2.9	2.2	2,527	2,339
200	2.2	2.9	2,478	2,250
225	1.3	3.6	2,431	2,164
250	0.0	4.5	2,383	2,081
275	-1.7	5.5	2,337	2,000
300	-3.8	6.7	2,290	1,922
325	-6.4	8.0	2,245	1,846
350	-9.3	9.3	2,200	1,773
375	-12.8	10.8	2,155	1,701
400	-16.6	12.5	2,111	1,633
425	-21.0	14.2	2,067	1,566
450	-25.8	16.0	2,024	1,501
475	-31.2	18.1	1,982	1,439

500	-37.0	20.1	1,939	1,377

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Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
0	-1.5	0.0	2,880	3,039
25	-0.7	0.0	2,828	2,929
50	-0.2	0.2	2,776	2,823
75	0.1	0.4	2,725	2,721
100	0.0	0.7	2,675	2,621
125	-0.4	1.1	2,625	2,524
150	-1.0	1.6	2,575	2,430
175	-2.0	2.2	2,527	2,339
200	-3.4	2.9	2,478	2,250
225	-5.0	3.6	2,431	2,164
250	-7.1	4.5	2,383	2,081

275	-9.5	5.5	2,337	2,000
300	-12.4	6.7	2,290	1,922
325	-15.6	8.0	2,245	1,846
350	-19.4	9.3	2,200	1,773
375	-23.5	10.8	2,155	1,701
400	-28.1	12.5	2,111	1,633
425	-33.2	14.2	2,067	1,566
450	-38.7	16.0	2,024	1,501
475	-44.9	18.1	1,982	1,439
500	-51.4	20.1	1,939	1,377

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Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
0	-1.5	0.0	3,050	3,408
25	-0.1	0.0	2,996	3,288

50	1.0	0.1	2,942	3,171
75	1.8	0.3	2,889	3,058
100	2.4	0.6	2,837	2,948
125	2.8	1.0	2,785	2,841
150	2.8	1.5	2,734	2,738
175	2.6	2.0	2,683	2,638
200	2.0	2.7	2,633	2,540
225	1.2	3.4	2,584	2,446
250	0.0	4.2	2,535	2,354
275	-1.5	5.2	2,487	2,265
300	-3.4	6.1	2,439	2,179
325	-5.6	7.2	2,391	2,095
350	-8.2	8.5	2,345	2,014
375	-11.2	9.9	2,298	1,935
400	-14.6	11.4	2,253	1,859
425	-18.5	13.0	2,207	1,785
450	-22.8	14.7	2163	1713

475	-27.6	16.6	2,118	1,644
500	-32.8	18.5	2,075	1,577

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Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
0	-1.5	0.0	3,200	4,092
25	-0.3	0.0	3,149	3,964
50	0.7	0.1	3,099	3,839
75	1.5	0.3	3,050	3,717
100	2.1	0.5	3,001	3,599
125	2.4	0.8	2,952	3,484
150	2.4	1.2	2,905	3,372
175	2.2	1.6	2,857	3,263
200	1.8	2.2	2,810	3,157
225	1.0	2.8	2,764	3,053

250	0.0	3.5	2,718	2,953
275	-1.3	4.3	2,673	2,855
300	-3.0	5.2	2,628	2,760
325	-4.9	6.1	2,584	2,668
350	-7.1	7.1	2,540	2,578
375	-9.8	8.3	2,496	2,490
400	-12.6	9.4	2,453	2,404
425	-15.9	10.7	2,410	2,321
450	-19.6	12.1	2,368	2,240
475	-23.7	13.6	2,326	2,162
500	-28.2	15.2	2,284	2,085

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Range (yd.)	Drop (in.)	Wind Drift (in.)	Velocity (fps)	Energy (ft.-lb.)
0	-1.5	0.0	3,200	4,092

25	-0.2	0.0	3,149	3,964
50	1.0	0.1	3,099	3,839
75	1.9	0.3	3,050	3,717
100	2.6	0.5	3,001	3,599
125	3.0	0.8	2,952	3,484
150	3.2	1.2	2,905	3,372
175	3.1	1.6	2,857	3,263
200	2.7	2.2	2,810	3,157
225	2.1	2.8	2,764	3,053
250	1.2	3.5	2,718	2,953
275	0.0	4.3	2,673	2,855
300	-1.5	5.2	2,628	2,760
325	-3.3	6.1	2,584	2,668
350	-5.4	7.1	2,540	2,578
375	-7.9	8.3	2,496	2,490
400	-10.7	9.4	2,453	2,404
425	-13.9	10.7	2,410	2,321

450	-17.4	12.1	2,368	2,240
475	-21.4	13.6	2,326	2,162
500	-25.7	15.2	2,284	2,085

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Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	Co (M
0	2580	2070	-1.75	
25	2,545	2,015	-0.2893	-1
50	2,511	1,961	0.8337	1
75	2,477	1,908	1.6128	2
100	2,443	1,857	2.0384	1
125	2,410	1,806	2.1003	1
150	2,376	1,756	1.7875	1
175	2,343	1,707	1.0913	0
200	2,310	1,660	0	

225	2,277	1,613	-1.4988	-0
250	2,245	1,567	-3.4157	-1
275	2,212	1,522	-5.7625	-2
300	2,180	1,478	-8.5537	-2
325	2,148	1,435	-11.8016	-3
350	2,116	1,392	-15.5195	-4
375	2,084	1,351	-19.7216	-5
400	2,052	1,310	-24.4248	-5
425	2,021	1,270	-29.6425	-6
450	1,990	1,231	-35.3907	-7
475	1,958	1,193	-41.6884	-8
500	1,927	1,155	-48.5516	-9
525	1,896	1,118	-55.9986	-1
550	1,865	1,081	-64.0494	-1
575	1,834	1,046	-72.7245	-1
600	1,802	1,010	-82.0449	-1
625	1,771	975	-92.0322	-1

650	1,740	941	-102.714	-1
675	1,709	908	-114.111	-1
700	1,677	875	-126.251	-1
750	1,615	811	-152.875	-1
800	1,553	750	-182.827	-2
850	1,491	692	-216.378	-2
900	1,430	636	-253.835	-2
950	1,368	582	-295.537	-2
1000	1,308	532	-341.879	-3
1050	1,247	484	-393.297	-3
1100	1,188	439	-450.297	-3
1150	1,130	397	-513.448	-4
1200	1,080	363	-583.389	-4
1250	1,044	339	-660.752	-5
1300	1,017	321	-746.064	-5
1350	997	309	-839.755	-5
1400	981	299	-942.16	-6

1450	967	291	-1053.57	-6
1500	953	283	-1174.25	-7

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Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	Co (M
0	2,960	3,464	-1.75	
50	2,876	3,270	-0.3503	-0
100	2,793	3,084	0	
150	2,711	2,905	-0.7638	-0
200	2,629	2,733	-2.7082	-1
250	2,549	2,568	-5.9106	-2
300	2,469	2,410	-10.4487	-3
350	2,390	2,259	-16.4104	-4
400	2,312	2,114	-23.8933	-5
450	2,236	1,976	-32.9989	-7
500	2,160	1,845	-43.8426	-8

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Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	Co (M
0	2,960	3,464	-1.75	
50	2,888	3,297	-0.3496	-0
100	2,816	3,136	0	
150	2,746	2,980	-0.7422	-0
200	2,675	2,829	-2.6328	-1
250	2,605	2,684	-5.7344	-2
300	2,536	2,543	-10.1191	-3
350	2,468	2,408	-15.8535	-4
400	2,400	2,278	-23.0117	-5
450	2,333	2,153	-31.6777	-6
500	2,267	2,032	-41.9414	-8

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Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	Co (N
0	2,960	3,464	-1.75	
50	2,897	3,318	-0.4063	-0
100	2,835	3,176	0	
150	2,773	3,039	-0.6719	-0
200	2,711	2,907	-2.5	-1
250	2,651	2,778	-5.5156	-
300	2,590	2,653	-9.7656	-3
350	2,530	2,531	-15.2891	-4
400	2,471	2,414	-22.1953	-5
450	2,412	2,300	-30.5156	-6
500	2,354	2,190	-40.3281	-7

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Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	Co (M
0	2,960	3,464	-1.75	
50	2,880	3,280	-0.3519	-0
100	2,802	3,104	0	
150	2,724	2,934	-0.7549	-0
200	2,647	2,771	-2.679	-1
250	2,571	2,613	-5.8431	-2
300	2,496	2,462	-10.3199	-3
350	2,421	2,317	-16.1917	-4
400	2,347	2,178	-23.5435	-5
450	2,274	2,044	-32.4729	-6
500	2,202	1,917	-43.0823	-8

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Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	Co (M
0	2,580	2,070	-1.75	
25	2,545	2,015	-0.2893	-1
50	2,511	1,961	0.8337	1
75	2,477	1,908	1.6128	2
100	2,443	1,857	2.0384	1
125	2,410	1,806	2.1003	1
150	2,376	1,756	1.7875	1
175	2,343	1,707	1.0913	0
200	2,310	1,660	0	
225	2,277	1,613	-1.4988	-0
250	2,245	1,567	-3.4157	-1
275	2,212	1,522	-5.7625	-2
300	2,180	1,478	-8.5537	-2
325	2,148	1,435	-11.8016	-3

350	2,116	1,392	-15.5195	-4
375	2,084	1,351	-19.7216	-5
400	2,052	1,310	-24.4248	-5
425	2,021	1,270	-29.6425	-6
450	1,990	1,231	-35.3907	-7
475	1,958	1,193	-41.6884	-8
500	1,927	1,155	-48.5516	-9
525	1,896	1,118	-55.9986	-1
550	1,865	1,081	-64.0494	-1
575	1,834	1,046	-72.7245	-1
600	1,802	1,010	-82.0449	-1
625	1,771	975	-92.0322	-1
650	1,740	941	-102.714	-1
675	1,709	908	-114.111	-1
700	1,677	875	-126.251	-1

Return to main text

Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	Co (M
0	2,580	2,070	-1.75	
25	2,545	2,015	-0.2893	-1
50	2,511	1,961	0.8337	1
75	2,477	1,908	1.6128	2
100	2,443	1,857	2.0384	1
125	2,410	1,806	2.1003	1
150	2,376	1,756	1.7875	1
175	2,343	1,707	1.0913	0
200	2,310	1,660	0	
225	2,277	1,613	-1.4988	-0
250	2,245	1,567	-3.4157	-1
275	2,212	1,522	-5.7625	-2
300	2,180	1,478	-8.5537	-2
325	2,148	1,435	-11.8016	-3

350	2,116	1,392	-15.5195	-4
375	2,084	1,351	-19.7216	-5
400	2,052	1,310	-24.4248	-5
425	2,021	1,270	-29.6425	-6
450	1,990	1,231	-35.3907	-7
475	1,958	1,193	-41.6884	-8
500	1,927	1,155	-48.5516	-9
525	1,896	1,118	-55.9986	-1
550	1,865	1,081	-64.0494	-1
575	1,834	1,046	-72.7245	-1
600	1,802	1,010	-82.0449	-1
625	1,771	975	-92.0322	-1
650	1,740	941	-102.714	-1
675	1,709	908	-114.111	-1
700	1,677	875	-126.251	-1

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Range (yds.)	Velocity (fps)	Energy (ft.-lb.)	Trajectory (in.)	Co (M
0	2,680	2,234	-1.75	
25	2,645	2,175	-0.3822	-1
50	2,609	2,118	0.6735	1
75	2,575	2,061	1.4109	1
100	2,540	2,007	1.8209	1
125	2,506	1,953	1.8938	1
150	2,472	1,900	1.6214	1
175	2,438	1,849	0.9934	0
200	2,405	1,798	0	
225	2,371	1,748	-1.3684	-0
250	2,338	1,700	-3.1218	-1
275	2,305	1,652	-5.2739	-1
300	2,272	1,606	-7.8327	-2
325	2,240	1,560	-10.8137	-3

350	2,207	1,515	-14.2264	-3
375	2,175	1,471	-18.0842	-4
400	2,143	1,428	-22.4008	-5
425	2,111	1,386	-27.1904	-6
450	2,079	1,344	-32.4671	-6
475	2,048	1,304	-38.2454	-7
500	2,016	1,264	-44.5402	-8
525	1,985	1,225	-51.3712	-9
550	1,953	1,187	-58.7512	-10
575	1,922	1,149	-66.7006	-1
600	1,891	1,112	-75.2375	-1
625	1,860	1,076	-84.3807	-12
650	1,829	1,040	-94.1508	-1
675	1,797	1,005	-104.57	-14
700	1,766	970	-115.662	-15

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